Essays on Commodity Prices, Commodity Abundance and the Macroeconomy

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This dissertation is submitted in fulfillment of the requirements for the degree of

Doctor of Philosophy

April 2020

Declaration of Originality

I hereby declare that this thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.'

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Statement of Co-Authorship

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Paper 1: This submitted paper is located on Chapter 4.

Majumder, MK, Raghavan, M and Vespignani, J 2019, 'Oil Curse, Economic Growth and Trade Openness' submitted in the Journal of 'Energy Economics'.

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21 November 2019	21 November 2019	21 November 2019

Acknowledgments

This dissertation brings to conclusion of four wonderful years in which I have been a Ph.D. student in Economics and Finance at the University of Tasmania. I am grateful to all the souls who walked with me on this path, and many thanks to them who made these years so pleasant and enlightening, and memorable.

First and foremost, I would like to thank Almighty God for giving me the strength, knowledge, ability, and opportunity to undertake this study and to preserve and complete it satisfactorily. Without his blessings, I would not have had the wisdom or the physical ability to do so.

I express my gratitude to my Ph.D. supervisor, a distinct role model, Associate Professor Joaquin Vespignani, for his dedicated support throughout my academic journey at Tasmanian School of Business and Economics. His timely advice helped shape this dissertation and improved my research direction. He was always there to listen and give advice and showed me various ways of approaching research problems as well as the need to be persistent to accomplish my goals. I believe the completion of this dissertation would never be possible without his great supervision, comments, encouragement, and support. It is impossible for me to express my appreciation for him with words.

I also want to give a special thanks to my Ph.D. co-supervisor, Dr. Mala Raghavan, who has always supported me and shown great affection with both encouragement and challenges at the same time. Through her, I gained the confidence that I could be an effective academic scholar. She has been a wonderful mentor and co-author.

I want to remember the role of Professor Mardi Dungey in my early Ph.D. life as a co-supervisor. Unfortunately, she recently passed away. She was an excellent personnel and subject-related expert. Thanks for your contribution and rest in peace Professor Mardi Dungey.

I thank my parents, and sibling Sabuj Kanti Majumder, for always being supportive of my education. I am also grateful to other family members and friends in Bangladesh who have supported me along the way.

I would like to thank all my colleagues and friends at the Tasmanian School of Business and Economics, University of Tasmania for their support at various stages of my research project and the writing of this dissertation: Dr. Paul Blacklow, Moses Kangogo, Abu Sayeed, Biplob Chowdhury, Graham Gourlay.

Most importantly, I would like to thank my friend, Ripon Kumar Mondal (Ph.D. candidate, Griffith University), Nahidul Haque Samrat, Anissuzaman Novel, Fakhrul Islam Monju, Anwarul Kaium, Habibul Hasan, Omi bhai, Ashraf bhai, Anas bhai, Kamrul bhai, and Selim bhai for their great friendship over the past four years and numerous helpful discussions throughout my studies in Australia, whenever I needed it.

Capstone Editing provided copyediting and proofreading services, according to the guidelines laid out in the university-endorsed national 'Guidelines for Editing Research Theses'.

I would like to thank one of my favorite Bangla television Stand-up comedy reality shows 'Mirakkel Akkel Challenger' especially Mir Afsar Ali and his team. This program helps me a lot to overcome some difficult moments by refreshing my mind and brain in many times.

A final thank you goes to the School of Business and Economics, University of Tasmania for their financial assistance and continued support throughout my graduate student career, and the nurturing academic environment they have provided. Thank you!

Preface

The essays in this dissertation represent collaborative efforts with my supervisors. Chapter 2 is a joint work with Associate Professor Joaquin Vespignani, Dr. Mala Raghavan, and Professor Mardi Dungey. Chapters 3 and 4 are based on joint work with Associate Professor Joaquin Vespignani, and Dr. Mala Raghavan.

Dedication

To my parents, Dhirendra Chandra Majumder and Sadhana Rani Mazumder, who instilled in me a passion for learning and made all the sacrifices for my success in life.

Abstract

This dissertation consists of three independent but related studies based on the relationship between commodity prices, commodity abundance and the macroeconomy. Commodity prices play an important role in economic growth and prosperity, especially in commodity abundance countries. However, these countries are frequently exposed to commodity price volatility, which causes a high degree of uncertainty in the economy, reducing investment and economic growth. This affects government fiscal balance and consequently external debt. To consider this, the dissertation consists of three essays. The first essay examines the impact of commodity price volatility on fiscal balance, the second essay explores the relationship between commodity price volatility and external debt, and the third essay investigates the role of trade openness on the oil curse.

The main objective of the first essay is to explore the impact of commodity price volatility on the government's fiscal balance. Using a dynamic panel data model for 108 countries from 1993 to 2018, this study finds that governments' fiscal balances decrease with commodity price volatility. A one standard deviation increase in commodity price volatility leads to a decrease of approximately 0.04 units in the fiscal balance as a percentage of gross domestic product (GDP). In addition, we examine the role of real interest rates in influencing the relationship between commodity price volatility and fiscal balance. The empirical results suggest that the negative impact of commodity price volatility on fiscal balance increases with higher real interest rates. The implication of this result is that, under the sticky-price assumption, an accommodative monetary policy could be effective in moderating the negative effect of commodity price volatility on fiscal balance.

The second essay investigates the relationship between commodity price volatility and external debt accumulation for 97 countries from 1993 to 2016. Using a dynamic panel data

model, this study finds that external debt accumulation increases with commodity price volatility. A one standard deviation increase in commodity price volatility contributes to a 0.17-units increase in external debt as a share of gross national income (GNI). Further, this study explores the impact of commodity price volatility on external debt under alternative exchange rate regimes. We find evidence suggesting that the effect is significantly higher for countries with a fixed exchange rate regime.

In the third essay, we re-examine the paradox that countries with abundant natural resources are poor in terms of real GDP per capita. This paradox, known as the 'resource curse', contradicts conventional intuition that natural resources improve economic growth and prosperity. Using dynamic panel data for 95 countries, this study revisits the 'resource curse' paradox in terms of oil resource abundance for the period 1980–2017. In addition, we study the role of trade openness in influencing the relationship between oil abundance and economic growth. The study finds that trade openness is a possible avenue to reduce the 'resource curse' problem because it allows countries to obtain competitive prices for their resources in the international market and to access advanced technologies to extract those resources more efficiently. Therefore, natural resource-rich economies can reduce the 'resource curse' by engaging in international trade.

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Chapter 1

Introduction

1.1. Introduction

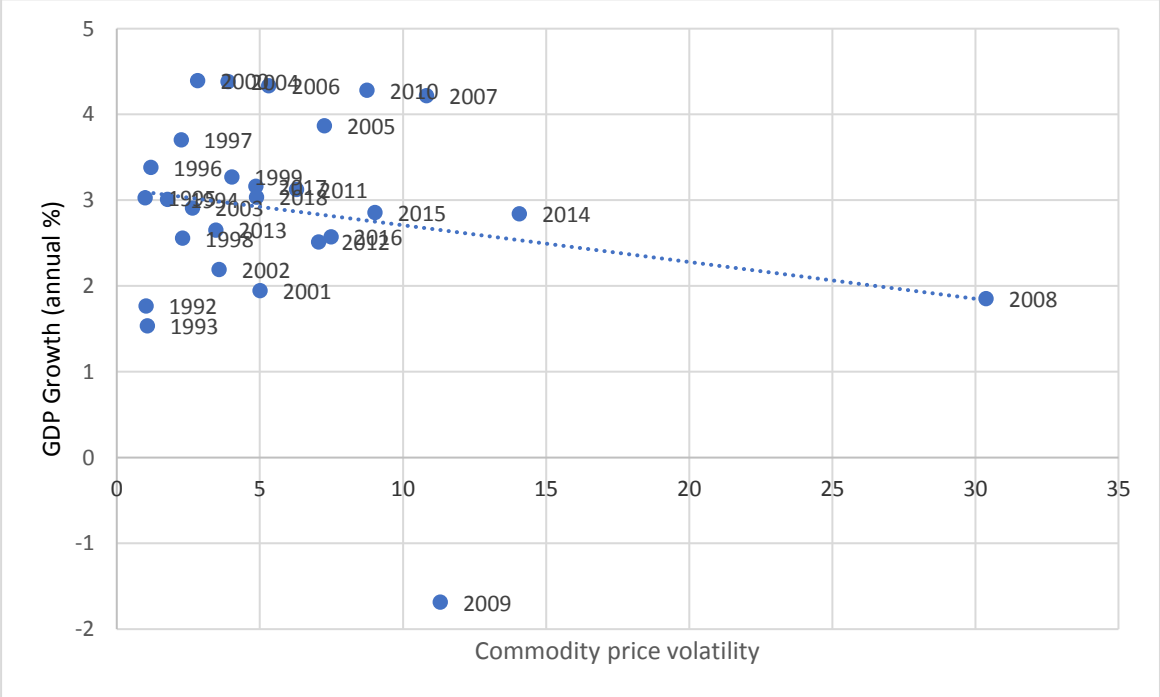
Conventional wisdom dictates that primary commodity abundance contributes to improved economic growth and development. In general, commodity prices affect the macroeconomy in different ways. First, the income stream from primary commodities increases real living standards by financing higher levels of public and private consumption. Second, commodity extraction can finance higher level of investment. Lastly, since income from commodities is typically managed by the public sector, governments can invest this revenue in public goods, (e.g., infrastructure, education, health). Therefore, it is expected that commodity endowments benefit economic growth and development.

However, in their seminal paper, Sachs and Warner (1995) and, thereafter, Gylfason (2000), Van der Ploeg (2011) and Cavalcanti, Mohaddes and Raissi (2012) claim that countries with abundant natural resources tend to grow more slowly than resource-poor countries—a phenomenon known as the 'resource curse'. The literature explains several economic and political factors that may contribute to lower economic growth, such as poor institutional quality, political rent-seeking, commodity price volatility and lack of diversification. Of these factors, commodity prices are set as exogenous for most open economies and are frequently exposed to commodity price volatility.[1] Thus, this dissertation focuses on the impact of commodity price volatility on the macroeconomy.

[1] Volatility is the degree of variation in the trading commodity prices series over time, as measured by standard deviation. According to Jacks, O'Rourke and Williamson (2011), since 1960, Latin American, South Asian and African primary commodity-exporting countries have faced three times higher volatility in terms of trade than manufacturing-exporting industrial economies.

Commodity price volatility generates uncertainty, makes it difficult to forecast future revenue from resource sectors and hinders effective planning for economic development (Badeeb, Lean & Clark 2017). In addition, Davis and Tilton (2005) argue that during periods of commodity price volatility, governments follow procyclical fiscal policies, which, in turn, may reduce the efficiency of both public and private investments. Therefore, commodity price volatility potentially contributes to lower economic growth. Figure 1.1 shows a negative relationship between global GDP growth rate and the global commodity price volatility index for the period from 1992 to 2018. The commodity price index includes all commodities i.e., both fuel and non-fuel commodities.

Figure 1.1: GDP growth and commodity price volatility



Source: Author's calculation based on the World Bank and International Monetary Fund (2019).

There is considerable literature exploring the impact of commodity price volatility on economic growth, but scant discussion of its relationship to fiscal policy issues. To fill this gap, we focus on the impact of commodity price volatility on the government's fiscal performance and external debt in the second and third chapters of this dissertation. An investigation of this

issue is fundamental because commodity price volatility generates uncertainty of future revenue from commodities and the variability of such revenues may result in changes to public expenditure as the government reassesses its expected revenue stream, generating significant adjustment costs. Given their dependence on highly volatile revenue sources, these economies face a significant challenge to achieving fiscal balance.[2] Therefore, the impact of commodity price volatility on the government's fiscal balance is investigated in Chapter 2.

In addition, Chapter 2 examines the role of the real interest rate in the relationship between commodity price volatility and fiscal balance. Our hypothesis is that lower real interest rates decrease the negative impact of commodity price volatility on fiscal balance by decreasing the cost of capital. As a result, it is expected that investment will increase with a lower real interest rate. During periods of slower economic growth, central banks (CB) can reduce the nominal interest rate. Due to the stickiness inflation assumption, the real interest rate decreases accordingly. Thus, the research questions for Chapter 2 are:

Research questions for Chapter 2: (i) Does commodity price volatility affect the government's fiscal balance? (ii) Does this effect differ in commodity-exporting and commodity-importing countries? And, (iii) Does the real interest rate can influence the relationship between commodity price volatility and the government's fiscal balance?

As fiscal balance decreases due to the commodity price volatility, governments borrow money from international financial markets, increasing the country's external debt (Brown & Gibson 2006). However, external debt unsustainability may take place if the government's debt/GDP becomes too large. Consequently, governments have decreased capacity to make debt repayments, which increases the probability of them becoming debt defaulters (Pattillo,

[2] For example, oil revenue constitutes more than 90% of total revenue in Venezuela, Saudi Arabia and Kuwait.

Poirson & Ricci 2002). Therefore, Chapter 3 of this dissertation explores the impact of commodity price volatility on external debt accumulation.

In addition, Chapter 3 explores the impact of commodity price volatility on external debt accumulation under alternative exchange rate regimes. Our hypothesis is that external debt increases with commodity price volatility under a fixed exchange rate regime. This is because such a regime does not allow immediate currency adjustments with commodity price changes. To keep the value of currency fixed, CBs purchase domestic currency and sell foreign currencies. This monetary contraction decreases the real output, increases fiscal deficit and, ultimately, increases external debt. Conversely, a floating exchange rate regime assists the economic stability of a country by responding to commodity price shocks through exchange rate adjustments. We classify the countries as fixed, managed floating and freely floating exchange rate regimes based on the exchange rate classification of Reinhart, Ilzetzki and Rogoff (2009). Therefore, we examine the following research questions in Chapter 3:

Research questions for Chapter 3: (i) Does external debt increase with commodity price volatility? (ii) Does this effect differ between commodity-exporting and importing countries? And, (iii) Do different exchange rate regimes play a significant role in external debt accumulation?

In addition to the commodity price volatility, the literature identifies some other factors responsible for lower economic growth in resource-abundant countries, for example, poor institutional quality, political rent-seeking, lack of diversification. However, several other factors remain unexplored. In Chapter 4 of this dissertation, we examine whether a country's trade openness may function as a potential channel to influence the resource curse. Our hypothesis is that trade openness reduces the effects of the curse by more efficiently reallocating resources. Therefore, the research question considered in Chapter 4 is:

Research question for Chapter 4: Does trade openness help reduce the oil curse?

In addition, Chapter 4 investigates the role of the World Trade Organization (WTO) in increasing international trade that reduces the resource curse. To consider this, we split our sample period into two subsample periods, that is: 1980–1994 (pre-WTO) and 1995–2017 (post-WTO).

Overall, this dissertation aims to provide a deeper understanding of the relationship between commodity prices and the macroeconomy. In all three main chapters, we investigate this relationship and provide empirical evidence of three different policy options to reduce the adverse impact of commodity abundance. Therefore, this study contributes to the literature supporting future studies and may have prospective policy implications.

Chapter 2

Commodity Price Volatility, Fiscal Balance and Real Interest Rate

2.1. Introduction

According to Bellemare, Barrett and Just (2013), Dwyer, Gardner and Williams (2011), Tujula and Wolswijk (2004) and Dehn (2000), commodity price volatility generates uncertainty in the economy, delays stability in government and private budgets, undermines the predictability of economic planning and potentially contributes to lower economic growth. In terms of governments' fiscal positions, commodity-exporting countries generally rely on commodity royalties. Fiscal positions in commodity-importing countries may also be affected, as some countries tax commodity imports heavily. Following Alley (2016), Spatafora and Samake (2012), Kaminsky (2010), and Tujula and Wolswijk (2004), we use fiscal balance as a measure of government's fiscal policy.

Fiscal balance is a sound representation of the government's fiscal policy because governments express annual targets as a flow term (e.g., balance or deficit), not in a static term, such as debt (Tujula & Wolswijk 2004). In this study, we define government's fiscal balance as the ratio between net lending and net borrowing. Fiscal balance improves when net lending is over net borrowing that means government is a lender or less indebtness. In other words, the measure of fiscal balance referring to the change in the stock of government's debt.

Our study explores the impact of commodity price volatility on fiscal balance for 108 countries in a panel data framework from 1993 to 2018. The countries and periods included are selected based on data availability from the World Bank (WB) and the International Monetary Fund (IMF). In addition, this study examines the role of real interest rate in influencing the relationship between commodity price volatility and government's fiscal balance.

Although considerable literature examines the relationship between the macroeconomy and commodity price volatility, there has been little consideration of commodity price volatility and fiscal position. To investigate these issues, this paper aims to undertake an empirical analysis of the relationship between commodity price volatility and fiscal balance by exploring the following research questions:

(i) How does commodity price volatility affect government's fiscal balance?

(ii) Are these effects different for commodity-exporting and commodity-importing countries?

(iii) How do real interest rates affect the nexus between commodity price volatility and fiscal balance? And,

(iv) Does this impact differ between disaggregated commodities?

In this study, we first estimate the impact of commodity price volatility on fiscal balance for all 108 countries. The sample countries are then divided into two subgroups—commodity-exporting and commodity-importing countries—to examine how the impact of commodity price volatility differs according to the level of commodity endowments.[3] This study also examines the effect of the 10 most-traded commodities' price volatilities on fiscal balance to examine the hypothesis that different commodity groups affect fiscal balance differently.[4]

In this study, we also examine the impact of real interest rates in reducing the negative impact of commodity price volatility on fiscal balance. Our hypothesis is that a lower real interest rate helps to decrease the adverse impact of commodity price volatility on fiscal balance. In periods of high commodity price volatility, CBs can reduce the nominal interest

[3] We select commodity-exporting countries by following Cavalcanti, Mohaddes and Raissi (2012), who classified countries as commodity exporters if the primary commodity constitutes more than 50 per cent of the country's total exports.

[4] The top 10 traded commodities are: crude oil, steel, soybean, iron ore, maize, gold, copper, aluminium, silver and gas.

rate to stimulate investments. Under the sticky-price assumption, this stimulates a corresponding decrease in the real interest rate. With lower real interest rates, firms find it less expensive to borrow to purchase capital equipment that boosts investment and increases aggregate demand. Therefore, a government may collect additional taxes to increase government revenues and, eventually, fiscal balance improves.

A dynamic panel data regression model is used in this study to explore the impact of commodity price volatility on fiscal balance.[5] Our empirical findings show that fiscal balance deteriorates with commodity price volatility in both the full sample and commodity-exporting countries. However, we do not find any statistically significant effect in commodity-importing countries. The empirical results also show that fiscal balance deteriorates with an increased real interest rate. The negative impact of commodity price volatility on fiscal balance also increases with a higher real interest rate.

This study relates to two strands in the existing literature. First, the literature addresses the nexus between commodity prices and fiscal balance. In the commodity-exporting countries, fiscal balance improves with an increase in commodity prices, as explained by Bleaney and Halland (2016), Murphy, Villafuerte and Ossowski (2010), Sinnott (2009), Kumah and Matovu (2007) and Böwer, Geis and Winkler (2007). Conversely, Spatafora and Samake (2012), Medina (2010) and Kaminsky (2010) argue that fiscal balance deteriorates with increased commodity prices. Here, we explore the impact of commodity price volatility on government's fiscal balance along with commodity price changes.

Second, this study is related to monetary policy literature. A higher real interest rate increases the cost of borrowing, which leads to lower investment (Malawi & Bader 2010) and

[5] Panel data allows the inclusion of data for *N* cross-sections and *T* time periods (Asteriou & Hall 2015). The combined panel data matrix set consists of a time series for each cross-sectional member in the data set and offer a variety of estimation methods. In this study, we have data for 108 countries and the time period is 26 years. Hence, a panel framework is an appropriate representation for this study.

higher unemployment (Doğrul & Soytas 2010). Higher interest rates increase the value of currency (currency appreciation), making domestic exports less competitive in the international market; therefore, government export revenue decreases with interest rate hikes.

The paper proceeds as follows. Section 2.2 reviews the literature. The methodology of this study is described in Section 2.3. We describe the data and variables in Section 2.4, and Section 2.5 presents the empirical results from panel data estimation. Finally, Section 2.6 provides the conclusion and directions for future study.

2.2. Literature review

The literature on the impact of commodity prices on fiscal balance is extensive; however, the effect of commodity price volatility remains unexplored. Kumah and Matovu (2007) find that fiscal balance improves in response to positive commodity price shocks in commodity-exporting countries. Similarly, using a panel regression model, Bleaney and Halland (2016), Murphy, Villafuerte and Ossowski (2010), Sinnott (2009), and Böwer, Geis and Winkler (2007) also find that government's fiscal balance in commodity-exporting countries improves with rising commodity prices.

Similarly, Céspedes and Velasco (2014) report that fiscal balance improves over time in commodity-exporting countries. In the 1970s commodity price boom, on average, fiscal balance increased by 0.03 per cent of GDP; in the 2000s, fiscal balance increased by 0.11 per cent of GDP. However, Spatafora and Samake (2012) and Kaminsky (2010) find that fiscal balance deteriorates in commodity-exporting countries. This implies that positive commodity price shocks may lead to strongly procyclical fiscal policies in these countries. However,

according to Keynesian theory and Barro's tax smoothing models, fiscal policy should be countercyclical.[6]

To explain procyclical behaviour, Talvi and Vegh (2005), Lane (2003), and Tornell and Velasco (2000) describe 'political distortion', which emerges due to the 'voracity effect'.[7] As a result of this effect, government spends more to achieve balance among the sectors of the country. Conversely, Duncan (2014) and Alesina, Campante and Tabellini (2008) claim that 'political rent' or 'rent-seeking' activities are responsible for the political distortion. During boom times, voters in the commodity-abundant countries demand immediate benefits in the form of public goods or lower tax rates. They fear that corrupt governments may spend extra revenue as 'political rent' or 'rent-seeking'.[8] To fulfill voters' demands, corrupt governments cannot accumulate additional income from a commodity windfall and thus, increase spending to satisfy voters to avoid becoming unpopular and losing power.[9] These studies only focused on commodity prices changes and did not consider commodity price volatility.

Some literature documents the response of fiscal positions to the output cycle rather than directly linking to commodity price cycles, that is, they indirectly link commodity price fluctuations to fiscal outcomes. These studies only examine the impact of commodity prices through their possible effects on GDP. According to Ilzetzki and Végh (2008), Talvi and Vegh (2005), Kaminsky, Reinhart and Vegh (2004), and Gavin et al. (1996) commodity-exporting countries follow procyclical fiscal policy, especially during periods of low growth. However,

[6] Countercyclical fiscal policy indicates that governments should decrease spending during the 'good times' and increase during 'bad times'. Conversely, pro-cyclical fiscal policy means that governments increase expenditure during 'good times' and decrease during 'bad times'.
[7] The voracity effect indicates that there exists a competition for funds among different units of the governments, such as ministries, provinces, et cetera. Governments deviate from the tax-smoothing model and are unable to run surpluses due to political distortions.
[8] In the theory, rent-seeking may be defined as any government, individual or group of people seek to increase their share of existing wealth without creating new wealth.
[9] Frankel (2011) argues that governments start investment in infrastructure and increase the salary of the government employees during the upturns.

this literature does not focus on the direct impact of commodity price volatility on fiscal positions.

We argue that this omission may have serious consequences for commodity-exporting countries because increased revenue originates mainly from commodity prices rather than from the output cycle. Woo (2003), De Haan, Sturm and Beekhuis (1999), Alesina and Perotti (1999), Roubini (1991), Edin and Ohlsson (1991), and Roubini and Sachs (1989) focus on the economic, political and institutional determinants of fiscal balance and do not consider commodity prices a determinant.

From the above discussion, it is clear that there is a lack of analysis on the impact of commodity price volatility on fiscal position. This study aims to fill the gap by studying the impact of commodity price volatility on fiscal balance. We use the most recent data available (up to 2018), which captures the effect of the recent global financial crisis (GFC) in 2007−2009 and the European debt crisis. Therefore, this study will be a valuable addition to the existing literature.

2.3. Methodology

To explore the impact of commodity price volatility on the fiscal balance, this study employs three dynamic panel data estimation models: (i) pooled ordinary least square (pooled OLS); (ii) fixed-effect (FE) and (iii) random effect (RE) models, which are commonly used in the literature.[10] In this section, we describe the FE model and apply it as the baseline model, as the Hausman test suggests that this model is appropriate for this study. The two remaining models (pooled OLS and RE) are used for robustness and descriptions of their use are presented in Appendix 2.2.

[10] We do not use period fixed effect models, period random effect models and combine effects (both cross-section and period fixed) models because commodity price data is fixed in cross-section levels. We mainly use EViews 9.5 version software for the data analysis and models estimation throughout the thesis.

2.3.1. Fixed-effect (FE) model

The FE model essentially captures all effects that are specific to a country and that do not vary over time. This means that the model controls for unobserved heterogeneity when it remains constant over time and is correlated with all dependent and independent variables. For example, fiscal balance, GDP, capital, real interest rate and military expenses will vary between countries due to their different geographies, natural endowments, political and cultural systems and other basic factors that vary between countries, but not overtime. To explore the impact of commodity price volatility on fiscal balance, we estimate the following model:

$$FB_{i,t} = \beta_{0i} + \beta_1 FB_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 CAP_{i,t} + \beta_5 GDP_{i,t} + \beta_6 MI_{i,t} + \beta_7 RIR_{i,t} + \beta_8 RIR_{i,t} * CPV_{i,t} + \varepsilon_{i,t} \quad (2.1)$$

Where β_{0i} is the unobserved time-invariant individual effect. $FB_{i,t}$ is the fiscal balance (% of GDP) whereas $FB_{i,t-1}$ represents the lag in fiscal balance (% of GDP). $CPV_{i,t}$ represents commodity price volatility and $PCCP_{i,t}$ indicates the percentage change in commodity prices. $CAP_{i,t}$ and $GDP_{i,t}$ represent capital growth (annual %) and GDP per capita growth (annual %), respectively. $MI_{i,t}$ and $RIR_{i,t}$ indicate military expense (% of GDP) and real interest rate (annual %), respectively. Comprehensive descriptions of the data and details about the sources of all variables are presented in Table A 2.1 in Appendix 2.1.

The subscripts i and t denote the country and time period, respectively. The idiosyncratic disturbance term is denoted by $\varepsilon_{i,t}$. By using lag dependent variable, we capture autocorrelation in the model. In this study, we also include an interaction term in equation (2.1), denoted by $RIR_{i,t} * CPV_{i,t}$, to examine the hypothesis that a lower real interest rate reduces the negative impact of commodity price volatility on fiscal balance.

Fiscal balance ($FB_{i,t}$): A wide variety of fiscal measures is available, including deficits and debts, and nominal or cyclically adjusted data. Fiscal balance is a sound representation of

the government's fiscal policy because governments express annual targets as a flow term (e.g., balance or deficit), not in a static term, such as debt (Tujula & Wolswijk 2004).

Lagged Fiscal balance ($FB_{i,t-1}$): We include the lagged fiscal balance as an influencing variable to correct past budgetary imbalances. A significant change in budget deficits in the past may induce governments to absorb part of the recent increases. Changes in fiscal balance may also result from budgetary inertia, meaning that previous fiscal policy decisions, such as the implementation of tax reforms and significant spending reforms, can affect public finances in the following years. As a result, it is expected a positive sign in this variable.

Commodity price volatility ($CPV_{i,t}$): According to Prebisch (1962), Cuddington, Ludema and Jayasuria (2002), Jacks, O'Rourke and Williamson (2011) and others, primary commodity prices are more volatile than those of manufactured goods and services. In particular, after the recent GFC in 2007–2009, commodity price volatility increased considerably (Omojolaibi & Egwaikhide 2014). As a result, government revenue tends to be more volatile—along with government spending and the fiscal balance. Therefore, we expect a negative (-) sign in this variable.

Percentage change in commodity prices ($PCCP_{i,t}$): It is expected that commodity prices positively affect fiscal balance in commodity-exporting countries because government finance is heavily dependent on the revenue of primary commodity exports. During boom periods, tax formulae dictate that profits are subject to higher marginal tax rates. Similarly, during difficult times, government may lower the tax burden on the natural resource sector. A commodity-importing country's fiscal balance is also influenced by the commodity prices through the trade tax. It is expected a positive (+) sign in this variable. We expect a positive relation between fiscal balance and commodity price changes.

Capital growth ($CAP_{i,t}$): Capital formation is an important element of fiscal balance. Capital growth improves economic growth and prosperity (Milesi-Ferretti & Moriyama 2006), which increase investment and employment in the economy. Fiscal balance increases with rising tax revenues and decreased government expenditure on social benefits. Eventually, government fiscal balance increases with the increased capital growth. Therefore, we expect a positive (+) sign of this vaiable.

GDP growth per capita ($GDPER_{i,t}$): It is expected that government fiscal balance increases with increased GDP per capita growth. Tax payable citizens pay more taxes with higher per capita income. Therefore, government's tax revenue increases in line with fiscal balance. Therefore, we expect a positive (+) sign of this vaiable.

Military expense ($LM_{i,t}$): According to Cappelen, Gleditsch and Bjerkholt (1984), increased military expenditure reduces economic growth. As this expenditure increases, so does total government expenditure, leading to higher tax rates in the private sector, which ultimately reduce private investment and eventually decrease the fiscal balance. It is expected that there is a negative (-) sign in this variable.

Real interest rate ($RIR_{i,t}$): A higher real interest rate causes lower investment in the economy that leads to a lower government tax revenue and eventually lower fiscal balance. According to the Comley, Anthony and Ferguson (2002) high real interest rate decrease the capital stock that causes lower output and investment. Therfore, it is expected a negative (-) relationship between fiscal balance and higher real interest rate.

Using equation (2.1), we use estimates for the different groups of countries—(i) full sample, (ii) commodity-exporting and (iii) commodity-importing countries—to examine the hypothesis that the impact of commodity price volatility differs with the level of commodity endowments. By using equation (2.1), we also examine the impact of the 10 most-traded

commodities to test the hypothesis that the price volatility of various commodities affects fiscal balance differently.

2.4. Data and description of the variables

2.4.1. The data

To estimate the models, this study uses an unbalanced annual panel data dataset for 108 countries for the period 1993 to 2018.[11] The data for fiscal balance are collected from the World Economic Outlook (WEO), IMF. Other variables such as capital growth, GDP per capita growth, military expense, and real interest rate are obtained from the World Development Indicator (WDI), WB.

Data for commodity prices are obtained from the IMF primary commodity price data portal. We convert the data into the annual form by taking the average of monthly data. Commodity prices are expressed as an index using a 2016 base year, including both fuel and non-fuel price indices. The data for 10 most-traded commodities are collected from the same source. We estimate commodity price volatility from the commodity price index using the standard deviation.

Volatility is the degree of variation of a trading price series over time. Following Mondal and Khanam (2018), Arezki et al. (2014), and Aghion et al. (2009) this study uses standard deviation as a measure of the volatility of commodity price.[12] The advantage of this method is its simplicity: it does not depend on the unit of measurement. The literature includes other methods to estimate commodity price volatility. For example, Gilbert and Morgan (2010) apply the GARCH (Generalised Autoregressive Conditional Heteroskedasticity) model, which is often used for modeling volatility in financial markets (Huchet-Bourdon 2011). The model

[11] List of full sample (108) and commodity-expoting and commodity-importing countries are presented in Tables A 2.2 and A 2.3 in Appendix 2.1, respectively.
[12] Arezki et al. (2014) and Aghion et al. (2009) use standard deviation to estimate exchange rate volatility, and Mondal and Khanam (2018) use to calculate consumption volatility.

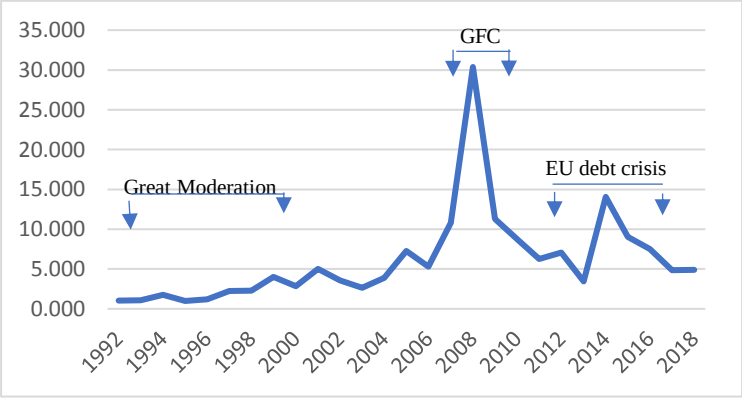
is based on the concept of estimating the conditional variance of innovation from the autoregressive process followed by a time series.

However, the main drawback of the GARCH approach is that the empirical results are dependent on the sampling frequency (Engle & Patton 2001). If a GARCH model is correctly specified for one frequency of data, then it will be misspecified for data with different time scales. Matthews (2010) use 'de-trend' as a measure of volatility. However, volatility measurement with this model may depend on the choice of the de-trending technique and thus, the estimation results may vary between models. We estimate commodity price volatility using monthly data to capture monthly price variation.[13] This overcomes the potential problem that the volatility occurs in the middle of the year such that the variation is hidden in the annual data. Commodity price volatility for each year is calculated by using standard deviation,

$$\sigma_t = \sqrt{\sum_{\tau=1}^{12} \frac{(P_\tau - \mu_t)^2}{12-1}} \tag{2.2}$$

where, σ_t = commodity prices volatility at time t, P_τ = observed monthly prices, μ_t = average price ($\mu_t = (1/12) \sum_{\tau=1}^{12} P_\tau$) , and τ = months (1, 2, 3 … 12)

Figure 2.1: Commodity price volatility



Source: Author's calculation based on IMF (2019)

[13] For example, with monthly data, the commodity price volatility in 2016 is computed as the commodity price volatility over the data from 2016:1 to 2016:12.

Figure 2.1 shows a significant spike in commodity price volatility during the GFC period of 2007–2009. From Figure 2.1, we also observe that in the pre-GFC periods (i.e., from the early-1990s to the mid-2000s), commodity price volatility was low, reflecting the period referred to as the 'Great Moderation'.[14]

We calculate the percentage change in commodity price as follows:

$$PCCP_t = \frac{P_{t2} - P_{t1}}{P_{t1}} X\ 100 \tag{2.3}$$

Where $PCCP_t$ = percentage change in commodity price, P_{t1} = commodity prices at time t_1 and P_{t2} = commodity prices at time t_2.

2.4.2. Unit root test, descriptive statistics and normality test

We use the Augmented Ducky-Fuller (ADF) and the Phillips-Perron (PP) tests to evaluate the stationary properties of all variables. The stationary variable is characterised by having a constant mean and variance over time, and the covariance between two values in the series depends on the length of time between the two values, but not on the actual times when the value is observed. Apart from commodity prices, all other variables included in the model are stationary at $\rho = 0.05$. However, the ρ-value of commodity prices is greater than 0.05, indicating that it is not stationary. To make this series stationary, we use the percentage change of the series. We present the unit root test, descriptive statistics and correlation matrix in Tables A 2.4, A 2.5, and A 2.6, respectively, in Appendix 2.1.

[14] "Great Moderation" refers to a reduction in the volatility of business cycle fluctuations starting in the mid–1980s. Bernanke (2004) hypothesize three potential causes for this economic stability: structural change in the economy, improved economic policy and good luck.

2.5. Results and discussion

In this section, we describe all empirical results estimated by FE model for all countries in the sample, and for commodity-exporting and commodity-importing countries. The result of the Hausman test indicates that the FE model fits the data in this study better than the RE model.[15]

2.5.1. Results for different country groups (full sample, commodity-exporting and commodity-importing countries)

Table 2.1 shows the results of the estimation of equation 2.1. In this section, we discuss the coefficients of the variables of interest (i.e., commodity price volatility, commodity price growth, real interest rate and the interaction term between commodity price volatility and real interest rate) estimated with the FE model. Coefficients of all other variables are consistent with literature. Columns 1, 2 and 3 in Table 2.1 represent the pooled OLS, FE and RE models, respectively. As shown in column 2, the coefficient on the commodity price volatility is negative (–0.04), indicating that governments' fiscal balance deteriorates with commodity price volatility in all countries in the sample. All being equal, a one standard deviation increase in commodity price volatility is associated with a significant deteriorate in fiscal balance of over –0.04 units as a share of GDP. The results are consistent across all three panel data estimation models (columns 1-3) and are statistically significant at the 1% level.[16]

Simultaneously, the positive coefficient of commodity price changes is 0.03, which indicates that governments' fiscal balance improves with rising commodity prices. If the other variables remain unchanged, a one-unit increase in commodity prices is associated with a fiscal balance improve of over 0.03 units (see Table 2.1, column 2). This implies that governments

[15] Hausman test results are presented in Appendix Table A 2.2.1.
[16] Given that the constant term is not that informative in the Pooled ordinary least square, and fixed effect and random effect estimation, I have not reported them in the tables where empirical results are presented.

do accrue additional revenues from the commodity prices windfall. The results are consistent across all three panel data estimation models and are statistically significant at the 1% level.

Table 2.1: Determinants of fiscal balance (full sample)

	Dependent variable: $FB_{i,t}$		
	pooled OLS	FE	RE
	(1)	(2)	(3)
$FB_{i,t-1}$	0.67***	0.52***	0.67***
	(0.01)	(0.01)	(0.01)
	[0.03]	[0.04]	[0.03]
$CPV_{i,t}$	–0.04***	–0.04***	–0.04***
	(0.01)	(0.01)	(0.01)
	[0.02]	[0.02]	[0.02]
$PCCP_{i,t}$	0.04***	0.03***	0.04***
	(0.003)	(0.005)	(0.003)
	[0.007]	[0.006]	[0.007]
$CAP_{i,t}$	–0.001	0.0005	–0.001
	(0.002)	(0.002)	(0.002)
	[0.002]	[0.002]	[0.002]
$GDP_{i,t}$	0.08***	0.09***	0.08***
	(0.01)	(0.02)	(0.01)
	[0.03]	[0.03]	[0.03]
$MI_{i,t}$	–0.21***	–0.98***	–0.21***
	(0.05)	(0.13)	(0.05)
	[0.07]	[0.28]	[0.07]
$RIR_{i,t}$	–0.02	–0.04***	–0.02*
	(0.01)	(0.01)	(0.01)
	[0.02]	[0.02]	[0.02]
$RIR_{i,t} * CPV_{i,t}$	–0.004***	–0.004***	–0.004***
	(0.001)	(0.001)	(0.001)
	[0.002]	[0.002]	[0.002]
R^2	0.50	0.57	0.50
Adjusted R^2	0.50	0.54	0.50
Periods	26	26	26
Countries	108	108	108
Observations	1937	1937	1937

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

The negative coefficient of the real interest rate indicates that fiscal balance deteriorates with an increase of the real interest rate. This result is consistent with the view of Comley, Anthony and Ferguson (2002) that a higher real interest rate causes lower capital stock and lower output due to reduced investment levels, resulting in lower fiscal balance. The coefficient

of the interaction term between commodity price volatility and real interest rate is also negative, indicating that the negative impact of commodity price volatility on fiscal balance increases with an increase in real interest rates. These results are statistically significant at the 1% level and consistent with all three models. The growth impact of a marginal increase in real interest rate implied from equation 2.1 is:

$$\frac{d(FB_{i,t})}{d(CPV_{i,t})} = -0.04 - 0.004\ (real\ interest\ rate)$$

The adverse impact of commodity price volatility on fiscal balance increases with higher real interest rates. The coefficient of commodity price volatility is –0.04 but when the value of the interaction term is added, the value of the coefficient increases in absolute term: $(-0.04 - 0.004 = |-0.044| > |-0.04|)$.

Table 2.2 shows results for the determinants of fiscal balance in the commodity-exporting and commodity-importing countries with pooled OLS, FE and RE models. The estimated coefficient for commodity price volatility is –0.07 in commodity-exporting countries (refer to column 2), which is higher than the full sample (see column 2 in Table 2.1), indicating that commodity price volatility has a larger impact in commodity-exporting countries. While these results are statistically significant at the 1% level those for commodity-importing countries are statistically insignificant (columns 4, 5 and 6).

Table 2.2 shows that the negative impact of commodity price volatility on fiscal balance increases with the increased real interest rates in commodity-exporting countries (column 2). This result is statistically significant at the 1% level. In general, commodity-exporting countries require a large amount of capital to extract commodities (e.g., oil, gas, metals). Therefore, a higher real interest rate increases the cost of borrowing capital, which dampens investment and outputs. Consequently, government revenue and fiscal balance decrease with a higher real interest rate in those countries. However, in commodity-importing countries, we do not find

any statistically significant influence of real interest rate on the relationship between commodity price volatility and fiscal balance with the FE model (column 5 in Table 2.2).

Table 2.2: Determinants of fiscal balance (commodity exporting and importing countries)

	Dependent variable: $FB_{i,t}$					
	Commodity-exporting countries			Commodity-importing countries		
	pooled OLS (1)	FE (2)	RE (3)	pooled OLS (4)	FE (5)	RE (6)
$FB_{i,t-1}$	0.68***	0.54***	0.68***	0.67***	0.51***	0.67***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.02]	[0.04]	[0.003]	[0.003]	[0.003]
$CPV_{i,t}$	–0.08***	–0.07***	–0.08***	–0.02	–0.02	–0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
$PCCP_{i,t}$	0.04***	0.04***	0.04***	0.04***	0.03***	0.04***
	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
	[0.01]	[0.008]	[0.01]	[0.006]	[0.004]	[0.006]
$CAP_{i,t}$	–0.0007	–0.00009	–0.0007	–0.003	0.002	–0.003
	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.006)
	[0.003]	[0.003]	[0.003]	[0.006]	[0.008]	[0.006]
$GDP_{i,t}$	0.09***	0.10***	0.09***	0.08***	0.09***	0.08***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
	[0.02]	[0.04]	[0.02]	[0.02]	[0.02]	[0.02]
$MI_{i,t}$	–0.30***	–1.02***	–0.30***	–0.17	–0.94***	–0.17
	(0.09)	(0.20)	(0.09)	(0.06)	(0.17)	(0.06)
	[0.09]	[0.24]	[0.09]	[0.06]	[0.20]	[0.06]
$RIR_{i,t}$	–0.02	–0.03*	–0.02	–0.02	–0.05***	–0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
$RIR_{i,t} * CPV_{i,t}$	–0.004*	–0.005***	–0.004*	–0.004**	–0.003	–0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]
R^2	0.54	0.60	0.54	0.48	0.55	0.48
Adjusted R^2	0.54	0.57	0.53	0.48	0.53	0.48
Periods	26	26	26	26	26	26
Countries	45	45	45	63	63	63
Observations	806	806	806	1131	1131	1131

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

Overall, government fiscal balance decreases with the increase in commodity price volatility in all countries in the sample and is particularly stronger for commodity-exporting countries. However, this impact is not statistically significant in commodity-importing

countries. The results also imply that lower real interest rates decrease the adverse effect of commodity price volatility on fiscal balance.

2.5.2. Results for disaggregated commodities

In this section, we discuss the impact of the 10 most-traded commodities' price volatilities on fiscal balance. Tables 2.3, 2.4 and 2.5 present the empirical results for the full sample, commodity-exporting and commodity-importing countries, respectively.

With few exceptions (i.e., maize, aluminium, coper and gas) the coefficients of all the other commodities' price volatilities are statistically significant and negative for the full sample (see Table 2.3). The estimated coefficient is larger in the case of metal commodities than energy and food commodity groups. One plausible reason for this is that metal price fluctuations over the last 150 years are characterised by three major super-cycles, which lasted between 20 and 70 years and the fourth super cycle is assumed to be underway (Jerrett & Cuddington 2008).

Among the energy prices, we find that the coefficient of oil price volatility is negative and statistically significant. Oil is considered a vital input in the production process and its price is more volatile than that of any other energy commodity (Rafiq, Salim & Bloch 2009). Regnier (2007) estimates that the crude oil price is 95% more volatile than other energy commodities because of its global demand and supply equilibrium. Among the food commodities, soybean price volatility is negative and statistically significant. One probable reason is that soybean is used to make different food (e.g., soybean oil and meat and dairy substitutes, including tofu and soy milk) and agricultural items (animal feed and biodiesel).

In Table 2.3, the interaction term is negative and statistically significant in the case of oil, steel, soybean, iron ore, silver, aluminium, coper and gas, indicating that a higher real interest rate increases the negative impact of these commodities' price volatility on fiscal balance. A higher interest rate increases the cost of capital, which decreases the fiscal balance.

For different primary commodities, investment requirements are different; for some, a large amount of capital and/or longer-term investments are required. For example, the investment time horizon for the oil industry is 5–7 years. Thus, with the lower interest rate, investors may earn increased revenue and pay more taxes to improve the fiscal balance.

From Table 2.4, we observe a similar pattern of results in commodity-exporting countries, except in the case of steel, iron ore, silver and soybean, where the coefficients are larger than those of the full sample. In the case of other commodities, the size of the coefficient is the same. From Table 2.5, we observe that some metal commodities' (steel, and iron ore) price volatilities have a statistically significant effect on fiscal balance. However, we do not find any statistically significant impact due to energy price volatility.

From the above discussion, we can conclude that the most-traded disaggregated commodities' price volatilities have a statistically significant negative impact on fiscal balance—and metal commodity price volatility has a larger impact than that of other commodity groups. A higher real interest rate increases the adverse effects of commodity price volatility on fiscal balance.

Table 2.3: Determinants of fiscal balance (full sample)

	Dependent variable: $FB_{i,t}$									
	Crude oil (1)	Steel (2)	Soybean (3)	Iron ore (4)	Maize (5)	Gold (6)	Copper (7)	Aluminium (8)	Silver (9)	Gas (10)
$FB_{i,t-1}$	0.56***	0.47***	0.54***	0.52***	0.54***	0.54***	0.56***	0.57***	0.54***	0.52***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.03]	[0.04]	[0.03]	[0.04]	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]	[0.03]
$CPV_{i,t}$	–0.02***	–0.09***	–0.02***	–0.07***	–0.007	–0.008***	–0.0002	–0.0001	–0.24***	0.003
	(0.006)	(0.02)	(0.005)	(0.01)	(0.0007)	(0.002)	(0.0002)	(0.0008)	(0.07)	(0.008)
	[0.007]	[0.02]	[0.002]	[0.02]	[0.007]	[0.003]	[0.0002]	[0.001]	[0.10]	[0.01]
$PCCP_{i,t}$	0.02***	0.03***	0.02***	0.003	0.01***	0.01***	0.03***	0.03***	0.01***	0.02***
	(0.003)	(0.005)	(0.004)	(0.002)	(0.004)	(0.005)	(0.003)	(0.004)	(0.003)	(0.003)
	[0.003]	[0.005]	[0.005]	[0.002]	[0.003]	[0.006]	[0.004]	[0.004]	[0.003]	[0.003]
$CAP_{i,t}$	–0.0001	0.0005	0.0006	0.0004	0.0006	0.0004	−0.0001	0.0003	0.0004	0.0006
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.001]
$GDP_{i,t}$	0.09***	0.06***	0.11***	0.10***	0.11***	0.11***	0.08**	0.09***	0.11***	0.10***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.03]	[0.04]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$MI_{i,t}$	–0.75***	–0.70***	–0.78***	–0.90***	–0.72***	–0.82***	–0.70***	–0.69***	–0.81***	–0.95***
	(0.12)	(0.14)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.13)
	[0.25]	[0.39]	[0.26]	[0.27]	[0.26]	[0.26]	[0.25]	[0.25]	[0.26]	[0.28]
$RIR_{i,t}$	–0.05***	–0.04***	–0.05***	–0.06***	–0.06***	–0.05***	–0.04*	–0.03***	–0.06***	–0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.02]	[0.02]	[0.02]	[0.02]	[0.03]	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
$RIR_{i,t} * CPV_{i,t}$	–0.002***	–0.004**	–0.0009**	–0.003**	–0.0007	−0.0006	–0.0001***	–0.0003***	–0.02***	–0.002**
	(0.0006)	(0.001)	(0.0004)	(0.001)	(0.0007)	(0.0002)	(0.00001)	(0.00001)	(0.006)	(0.0007)
	[0.001]	[0.002]	[0.001]	[0.002]	[0.0007]	[0.0004]	[0.0003]	[0.00001]	[0.01]	[0.002]
R^2	0.57	0.56	0.56	0.57	0.55	0.56	0.57	0.56	0.56	0.56
Adjusted R^2	0.55	0.53	0.53	0.54	0.53	0.54	0.55	0.54	0.54	0.54
Periods	38	32	38	38	38	38	38	38	38	26
Countries	108	106	108	108	108	108	108	108	108	108
Observations	2057	1531	2057	2057	2057	2057	2057	2057	2057	1937

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

Table 2.4: Determinants of fiscal balance (commodity-exporting countries)

	Dependent variable: $FB_{i,t}$									
	Crude oil	Steel	Soybean	Iron ore	Maize	Gold	Copper	Aluminium	Silver	Gas
$FB_{i,t-1}$	0.54***	0.39***	0.51***	0.46***	0.52***	0.50***	0.55***	0.56***	0.50***	0.53***
	(0.03)	(0.04)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
	[0.08]	[0.04]	[0.08]	[0.10]	[0.08]	[0.09]	[0.08]	[0.08]	[0.09]	[0.08]
$CPV_{i,t}$	–0.03***	–0.11***	–0.03***	–0.12***	–0.02**	–0.01***	–0.0004	–0.0008	–0.48***	0.002
	(0.009)	(0.03)	(0.008)	(0.02)	(0.01)	(0.003)	(0.0003)	(0.001)	(0.10)	(0.01)
	[0.01]	[0.03]	[0.01]	[0.05]	[0.01]	[0.008]	[0.0003]	[0.0009]	[0.20]	[0.02]
$PCCP_{i,t}$	0.03***	0.03***	0.02***	0.003	0.02***	0.02***	0.03***	0.03***	0.02***	0.02***
	(0.004)	(0.007)	(0.006)	(0.003)	(0.005)	(0.008)	(0.005)	(0.006)	(0.004)	(0.003)
	[0.005]	[0.006]	[0.006]	[0.003]	[0.004]	[0.009]	[0.005]	[0.007]	[0.004]	[0.003]
$CAP_{i,t}$	–0.0009	–0.0002	0.0001	–0.0002	0.0004	−0.0003	−0.0005	0.0001	0.0001	0.0001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.004]	[0.002]
$GDP_{i,t}$	0.11***	0.09***	0.14***	0.13***	0.13***	0.14***	0.10***	0.11***	0.14***	0.09***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.002]	[0.04]
$MI_{i,t}$	–0.88***	–0.71***	–0.89***	–1.08***	–0.83***	–0.99***	–0.82***	–0.78***	–0.99***	–0.93***
	(0.18)	(0.24)	(0.19)	(0.19)	(0.19)	(0.19)	(0.18)	(0.19)	(0.19)	(0.20)
	[0.26]	[0.21]	[0.29]	[0.26]	[0.28]	[0.27]	[0.27]	[0.27]	[0.27]	[0.29]
$RIR_{i,t}$	–0.04***	–0.04***	–0.05***	–0.07***	–0.06***	–0.06***	–0.04**	–0.02	–0.07***	–0.007
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
	[0.03]	[0.03]	[0.04]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.02]	[0.02]
$RIR_{i,t} * CPV_{i,t}$	–0.002**	–0.004**	–0.0008	–0.002	–0.0001	−0.0004	–0.0001***	–0.0004***	–0.01	–0.003**
	(0.0009)	(0.002)	(0.0007)	(0.002)	(0.001)	(0.0003)	(0.00002)	(0.0001)	(0.009)	(0.001)
	[0.001]	[0.003]	[0.001]	[0.005]	[0.0007]	[0.0008]	[0.0004]	[0.0001]	[0.02]	[0.002]
R^2	0.59	0.60	0.56	0.59	0.56	0.57	0.58	0.57	0.58	0.58
Adjusted R^2	0.56	0.56	0.54	0.56	0.53	0.55	0.55	0.55	0.55	0.55
Periods	36	30	36	36	36	36	36	36	36	26
Countries	45	44	45	45	45	45	45	45	45	45
Observations	839	617	839	839	839	839	839	839	839	806

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

Table 2.5: Determinants of fiscal balance (commodity-importing countries)

	Dependent variable: $FB_{i,t}$									
	Crude oil	Steel	Soybean	Iron ore	Maize	Gold	Copper	Aluminium	Silver	Gas
$FB_{i,t-1}$	0.56***	0.50***	0.55***	0.54***	0.54***	0.55***	0.56***	0.57***	0.55***	0.50***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.04]
$CPV_{i,t}$	–0.009	–0.07***	–0.01*	–0.04***	–0.002	–0.003	–0.00001	–0.0008	–0.09	0.005
	(0.007)	(0.02)	(0.007)	(0.01)	(0.01)	(0.003)	(0.0002)	(0.001)	(0.09)	(0.01)
	[0.008]	[0.03]	[0.007]	[0.02]	[0.009]	[0.003]	[0.0003]	[0.002]	[0.09]	[0.02]
$PCCP_{i,t}$	0.01***	0.02***	0.01*	0.002	0.009*	0.007	0.03***	0.02***	0.008**	0.01***
	(0.003)	(0.006)	(0.006)	(0.003)	(0.004)	(0.007)	(0.004)	(0.005)	(0.004)	(0.003)
	[0.02]	[0.007]	[0.008]	[0.003]	[0.004]	[0.008]	[0.006]	[0.005]	[0.004]	[0.08]
$CAP_{i,t}$	0.001	0.002	0.002	0.001	0.001	0.001	0.0007	0.001	0.001	0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
$GDP_{i,t}$	0.07***	0.03	0.09***	0.07***	0.09***	0.10***	0.07***	0.07***	0.08***	0.08***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.04]	[0.05]	[0.05]	[0.03]
$MI_{i,t}$	–0.69***	–0.67***	–0.73***	–0.81***	–0.67***	–0.74***	–0.64***	–0.64***	–0.72***	–0.96***
	(0.15)	(0.18)	(0.15)	(0.15)	(0.18)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)
	[0.35]	[0.53]	[0.37]	[0.39]	[0.36]	[0.37]	[0.35]	[0.35]	[0.36]	[0.37]
$RIR_{i,t}$	–0.05***	–0.04**	–0.04**	–0.05***	–0.06***	–0.04***	–0.04**	–0.04**	–0.05***	–0.05***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.04]	[0.04]	[0.001]	[0.04]	[0.03]	[0.03]	[0.04]	[0.02]
$RIR_{i,t} * CPV_{i,t}$	–0.001*	–0.003*	–0.0009	–0.003**	–0.001	−0.0006**	–0.0001	–0.0002**	–0.01**	–0.001
	(0.0007)	(0.001)	(0.0005)	(0.001)	(0.0009)	(0.0002)	(0.0001)	(0.00009)	(0.008)	(0.0009)
	[0.001]		[0.0008]	[0.002]	[0.001]	[0.0003]	[0.0004]	[0.0001]	[0.01]	[0.001]
R^2	0.56	0.55	0.56	0.56	0.55	0.56	0.57	0.56	0.56	0.57
Adjusted R^2	0.54	0.51	0.53	0.53	0.53	0.53	0.54	0.53	0.53	0.55
Periods	38	38	38	38	38	38	38	38	38	38
Countries	63	63	63	63	63	63	63	63	63	63
Observations	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

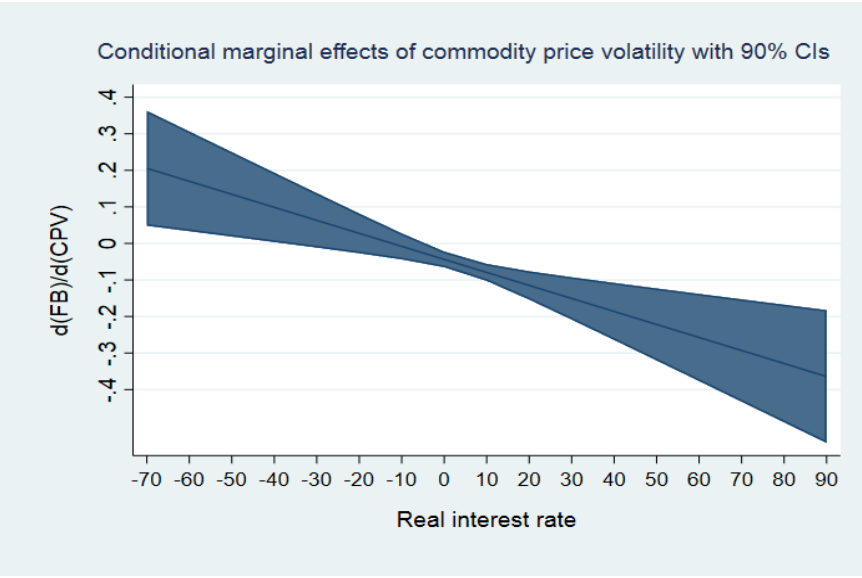
2.5.3. Marginal effect

Marginal effect measures the instantaneous rate of change in continuous variables. Marginal effect estimation provides a sound estimate of the degree of change in the dependent variable that will be produced by variation in the independent variables. In this study, we compute the marginal effect of commodity price volatility on fiscal balance in terms of real interest rates. Based on the estimates in Table 2.1, this produced:

$$\frac{d(FB_{i,t})}{d(CPV_{i,t})} = -0.04 - 0.004\,(Real\ interest\ rate) \tag{2.4}$$

From equation 2.4, we can see that the marginal effect of commodity price volatility on fiscal balance is a decreasing function of real interest rate. Figures 2.2a–c plot the marginal effect, $\frac{d(FB_{i,t})}{d(CPV_{i,t})}$, on the Y-axis and real interest rates on the X-axis.[17] From figure 2.2a, we can observe that the marginal effect of commodity price volatility on fiscal balance becomes negative with the increase of real interest rate that supports our empirical findings in Table 2.1.

Figure 2.2a: Marginal effect of commodity price volatility on fiscal balance (full sample)



[17] Marginal effect of the 10 most-traded commodity price volatilities are presented in Appendix 2.3.

Figure 2.2b: Marginal effect of commodity price volatility on fiscal balance (commodity-exporting)

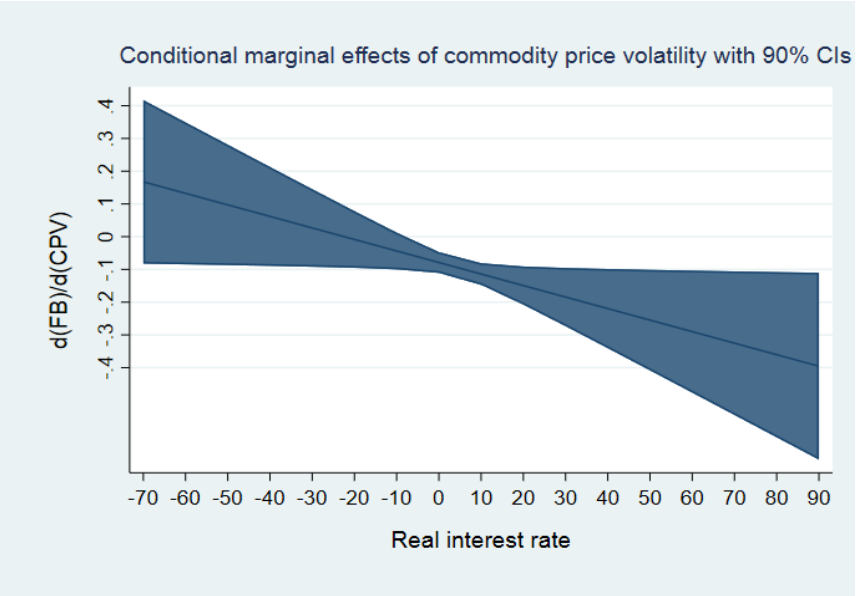
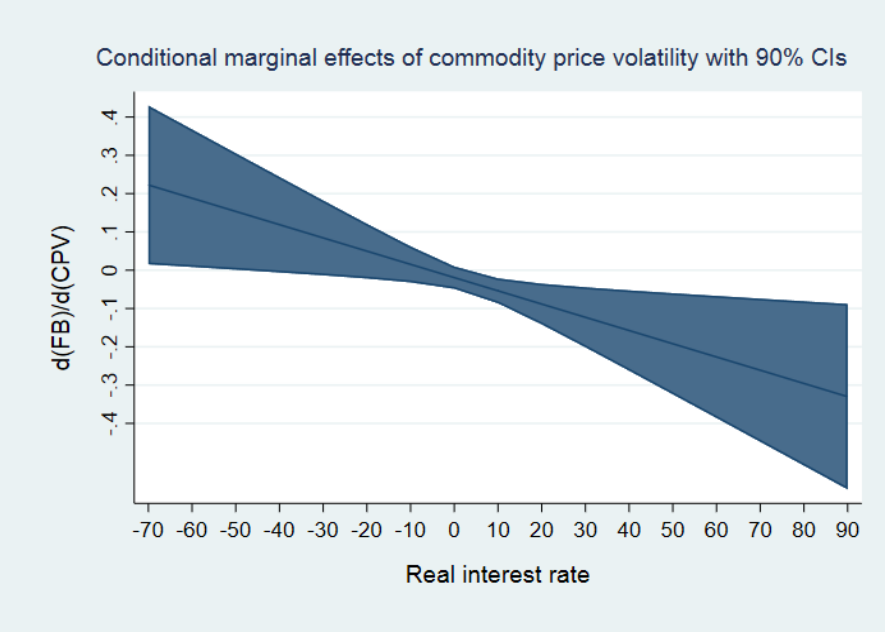


Figure 2.2c: Marginal effect of commodity price volatility on fiscal balance (commodity-importing)



2.6. Conclusion

This study explores the impact of commodity price volatility on fiscal balance. To understand its effect, a dynamic panel data regression model is estimated for 108 countries for the period from 1993 to 2018. Our empirical findings show that commodity price volatility has a negative and statistically significant effect on fiscal balance in the full sample and commodity-exporting countries. However, we do not find any statistically significant impact on commodity-importing countries.

This study also investigates the role of real interest rates in influencing the relationship between commodity price volatility and fiscal balance. Our empirical results indicate that the negative impact of commodity price volatility increases with increased real interest rates. A higher real interest rate increases the cost of borrowing, which decreases investment. Based on our empirical findings, we conclude that the adoption of a lower real interest rate will help to reduce the adverse effects of commodity price volatility on fiscal balance.

This study can be extended by identifying the effect of positive and negative volatility of commodity price on the government fiscal balance (asymmetric) using the Markov-Switching model given that there may be nonlinearities in this relationship.

Chapter 3

Commodity Price Volatility, External Debt and Exchange Rate Arrangements

3.1. Introduction

The increased external debt after the GFC renewed interest in the pervasiveness of sovereign debt sustainability.[18] This issue is particularly important for commodity-abundant economies. In general, commodity prices are an important driver of fiscal policy and business cycles in these countries.[19] Given their dependence on highly volatile revenue sources, these economies face a significant challenge in achieving fiscal balance.[20] Therefore, persistent fiscal deficit leads to an increase in external debt. This study explores the impact of commodity price volatility on external debt for 97 countries in a panel dataset from the period 1993 to 2016, subject to data availability from the WB and IMF.[21] Further, this study examines the role of alternative exchange rate regimes in influencing the impact of commodity price volatility on external debt accumulation.

Commodity price shocks can create a dilemma for countries when fiscal revenue largely depends on commodities. The risk being that revenue boosted by high commodity prices translate into long-lasting expenditure increasing external debt. For example, Algeria, Nigeria and Venezuela fell prey to over-optimistic spending habits during the 1970s commodity booms, using current and expected revenues to finance different development projects (Brown,

[18] External debt in low- and middle-income countries reached $7.1 trillion in 2017 from $3.6 trillion in 2008.
[19] For empirical evidence, see Céspedes and Velasco (2014), Spatafora and Samake (2012) and Medina (2010).
[20] For example, oil revenue constitutes more than 90% of total revenue in Venezuela, Saudi Arabia and Kuwait.
[21] In this study, we use total external debt stocks (% of gross national income) which is a debt owed to non-residents repayable in currency, goods, or services. Usually, government starts borrowing from internal and external sources when fiscal deficit increases. This study aims to explore how commodity price volatility affects the debt that is borrowed from foreign sources only because sovereign debt crisis issue arises due to the higher external debt. Therefore, government debt especially external debt arises due to the decrease in fiscal balance however these two are not a similar measure.

Crawford & Gibson 2008). Such projects became unsustainable when commodity prices declined and volatility increased. As the fiscal deficit increases, governments borrow money from international financial markets, which increases the country's government debt (Brown & Gibson 2006). In general, borrowing money helps to increase in economic growth rates by reducing the gap between domestic saving and investment. However, external debt sustainability may deteriorate if debt/GDP ratio becomes too large. Consequently, governments face a decreased capacity to make debt repayments and the probability of defaulting increases (Pattillo, Poirson & Ricci 2002).

Commodity prices are by nature more volatile than the prices of manufactured goods [see e.g., Radetzki and Wårell (2016), Jacks, O'Rourke and Williamson (2011) and Szirmai (2005)], making export revenue highly volatile, especially in commodity-exporting countries.[22] In this study, we select commodity-exporting countries following Cavalcanti, Mohaddes and Raissi (2012), who classified countries as commodity exporters if the primary commodity constitutes more than 50 per cent of the country's total exports.

Further, this study examines the role of different exchange rate regimes to absorb external shocks into the economy. We hypothesise that a fixed exchange rate regime magnifies the shocks, which became obvious after the Argentine currency and debt crisis in 2001–2002 (Edwards & Yeyati 2005). Under the fixed exchange rate mechanism, economic stability is delayed, awaiting adjustment of nominal wages, commodity prices or an increase in volatility of output and employment.[23] As a result, it is assumed that commodity price volatility increases external debt under a fixed exchange rate regime. In contrast, a floating exchange rate regime

[22] Jacks, O'Rourke and Williamson (2011) show that since 1960 Latin American, South Asian, and African primary commodity exporting countries face three times higher volatility in terms of trade than manufacturing-exporting industrial economies.

[23] Under a fixed exchange rate regime, the domestic currency is fixed to another currency or a basket of currencies. Whereas under a floating exchange rate regime, the nominal exchange rate is allowed to move freely in response to supply and demand conditions in the foreign exchange market.

may support the economic stability of a country by responding to commodity price shocks through exchange rate adjustments. In this study, we include a further classification: managed floating exchange rate regimes, wherein currencies can move within predetermined limits. Countries are classified according to the definition of Reinhart, Ilzetzki and Rogoff (2009).

Given the considerable literature on the relationship between the macroeconomy and commodity price volatility, but lack of information about commodity price volatility and external debt. This paper aims to undertake an empirical analysis of the relationship between commodity prices and commodity price volatility and external debt by exploring the following research questions:

(i) How does commodity price volatility affect external debt accumulation?

(ii) Are these effects different for commodity-exporting and commodity-importing countries? And,

(iii) Does the exchange rate regime matter for government debt accumulation in different country groups?

A dynamic panel data regression model is used in this study to explore the impact of commodity prices and commodity price volatility on external debt in different groups of countries.[24] The results show that there is a positive relationship between commodity price volatility and external debt: external debt increases with commodity price volatility in the full sample and commodity-exporting countries. We do not find any statistically significant impact of commodity price volatility on external debt in commodity-importing countries. Further, our empirical results show that commodity price volatility has no statistically significant impact on

[24] Panel data usually give the researchers a large number of data points, increasing the degrees of freedom and reducing the collinearity among explanatory variables-hence improving the efficiency of econometric estimates (Hsiao 2014). Also, given the rapid changes in global macroeconomic environment in the past years, the application of panel data approach seems to be highly preferred, as it allows to control time-specific events that are linked to overseas borrowing (Waheed 2017).

external debt in countries that use a floating exchange rate regime. In contrast, external debt increases with commodity price volatility in countries with more rigid exchange rate regimes.

This study relates to at least two strands of existing literature. First, this study is linked to work on the nexus between commodity prices and external debt, which have a negative relationship in commodity-exporting countries [see e.g., Swaray (2005), Hausmann and Gavin (1995), and Olukoshi (1989)]. In this study, we explore the impact of commodity price volatility on external debt along with commodity price changes.

Second, this study is related to the exchange rate regimes literature. The argument favors the floating exchange rate regimes established by Friedman (1953) and Mundell (1961), which state that floating exchange rates can better absorb external shocks than fixed exchange rates. This is because during the external shocks, floating exchange rates allow faster adjustment of relative prices and quantities. Dąbrowski and Wroblewska (2016), Hoffmann (2007), Edwards and Yeyati (2005), Ghosh et al. (1997), Flood and Rose (1995), and Baxter and Stockman (1989) empirically find that floating exchange rates can absorb external shocks faster than fixed rates. In contrast, Masson, Goldstein and Frenkel (1991), Aghevli, Khan and Montiel (1991) and Giavazzi and Pagano (1988) argue that a fixed exchange rate provides more fiscal discipline in light of the lax fiscal policies in developing countries.

The paper proceeds as follows. Section 3.2 reviews the literature. In Section 3.3, we describe the movements in commodity price volatility and external debt. In Section 3.4, we present the theory of the nexus between external shocks and exchange rate regimes. The methodology of this study is described in Section 3.5. We then describe the data and variables in Section 3.6 and Section 3.7 presents the empirical results from panel data estimation. Finally, Section 3.8 provides the conclusion and offers directions for future study.

3.2. Literature review

Lopez-Martin, Leal and Fritscher (2017), Arezki and Brückner (2012), Kamola (2007), Swaray (2005), among others, find a negative relationship between commodity price changes and government external debt burden, indicating that external debt decreases with increased commodity prices and vice-versa. The government can repay a portion of debt with the extra revenue accrued from the commodity windfalls. Conversely, Nooruddin (2008) finds that government debt burden increases with commodity price booms. This is due to the increase in government expenditure designed to expand infrastructure and improve non-commodity productive capacity.

Another reason is that rapid commodity price increases encourage corrupt and rent-seeking behaviour and exacerbate societal tensions when the distribution of commodity revenues is not considered equitable (Ndikumana & Boyce 2000, and Ajayi 1991).[25] Further, the higher volatility in revenues reduces the time horizons of policy actors who feel compelled to spend revenues when they are available. Overall, these various effects of revenue volatility result in rising fiscal deficits, the financing for which governments obtain through external borrowing (Edo 2002). These studies only focused on the impact of commodity price on external debt and no attention was given to commodity price volatility.

From a political economy perspective, Alesina and Tabellini (1990) developed a theoretical framework that describes the role of democracy and a coalition form of government in external debt accumulation. They argue that the incumbent government might burden a rival party coming into power with high debt to be repaid in the future. This often occurs in

[25]In public choice theory and economics, rent-seeking involves aiming to increase one's share of existing wealth without creating new wealth. Rent-seeking results in reduced economic efficiency through poor allocation of resources, reduced actual wealth-creation and lost government revenue.

democratic systems where there is the uncertainty of re-election, and outgoing governments may deliberately undermine a new incoming government by accumulating external debt.

Similarly, Edin and Ohlsson (1991) and Roubini and Sachs (1989) find that government debt increases with the coalition form of government. Further, Chiminya, Dunne and Nikolaidou (2018) find that democratic governments accumulate more debt from external sources than do autocratic governments because creditors may lend more to democratic institutions. Additionally, democratic governments increase spending on infrastructure and social safety net programs to motivate voters to vote for them again. However, this leads to the accumulation of more debt when compared to autocratic regimes that may not need to be voted into power.

Some of the current literature documents the reaction of public debt positions to the output cycle rather than in direct response to commodity price cycles (i.e., only indirectly linking commodity price fluctuations with external debt accumulation), linking the impact of commodity prices only through their possible effect on GDP. According to Bittencourt (2015), Forslund, Lima and Panizza (2011), and Barro (1979) there is a countercyclical relationship between output cycles and public debt, indicating that public debt decreases with the development of national income. However, these studies do not focus on the direct impact of commodity price cycles on government debt policy. We argue that this omission may be a serious issue for commodity abundance countries where a significant share of revenue is from commodity royalties rather than from the output cycle. A summary of the most relevant literature concerning the determinants of government debt is presented in Table 3.1.

Table 3.1: Summary of the literature concerning determinants of government debt

Author(s)	Countries	Periods	Technique(s)	Determinants
Roubini and Sachs (1989)	Industrial countries	1960–1985	pooled OLS	GDP Growth, interest rate, unemployment, govt. types
Colombo (2009)	61 developing countries	1970–2010	pooled OLS	GDP per capita, trade openness, education level, floating exchange rate, financial depth, IQ, inflation,
Arezki and Brückner (2012)	93 developing and emerging countries	1970–2007	FE	Commodity price shocks, polity2
Forslund, Lima and Panizza (2011)	104 developing and emerging countries	1990–2007	pooled OLS	GDP, REER
Swamy (2015)	82 developing and developed countries	1980–2009	Panel-GMM	FDI, GDP growth, inflation, population growth, trade openness, expenditure.
Chiminya and Nicolaidou (2015)	36 Sub-Saharan African countries	1975–2012	Pooled OLS and FE	Trade openness, population, GDP Growth, RIR, Inflation, polity2,
Lau and Lee (2016)	Thailand, the Philippines	1976–2013	VAR	CPI, RIR, GDP, m2
Cooray, Dzhumashev and Schneider (2017)	126 developing countries	1996–2012	pooled OLS, FE, GMM and IV	Shadow economy, corruption, government's expenditure
Waheed (2017)	24 oil-exporting and importing countries	2004–2013	pooled OLS	GDP, CAB, FDI, inflation, oil price, expenditure

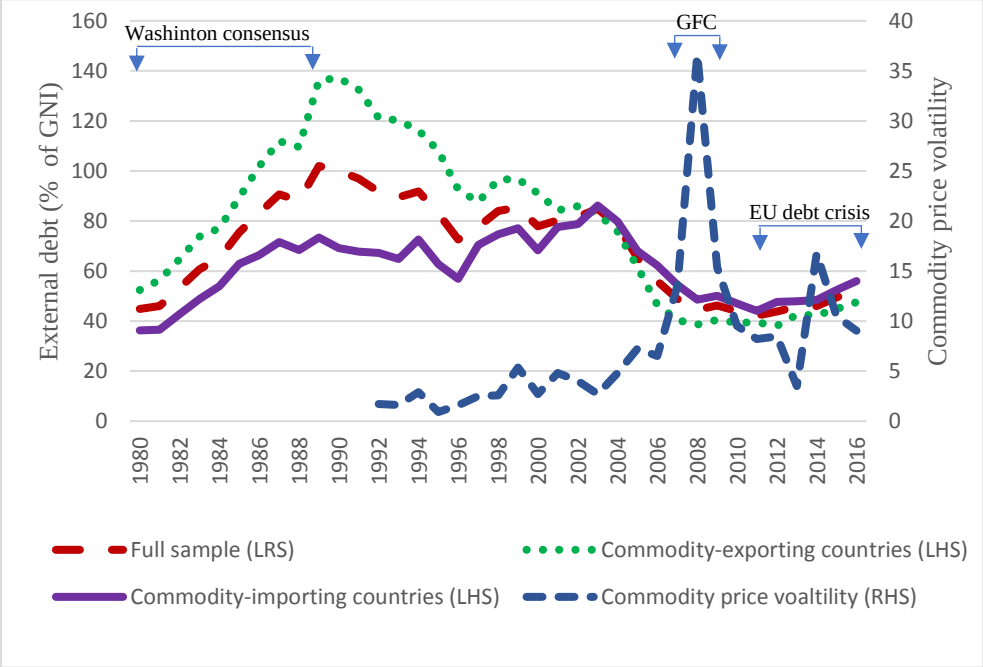
Here, pooled OLS = Pooled ordinary least square, FE = Fixed-effects model, DOLS = Dynamic OLS model, GMM = Generalised method of moments model, IV = Instrumental Variables, VAR = Vector Autoregressive model, REER = Real Effective Exchange Rate, RIR = Real Interest Rate, CPI = Consumer Price Index. FDI = Foreign Direct Investment, M2 = Money Supply.

While the effect of commodity prices on government external debt policies has been studied in the literature, there is a lack of analysis of the impact of commodity price volatility on government debt policies. We aim to fill the gap by studying the impact of commodity price volatility on external debt rather than focusing only on commodity prices. Moreover, this study examines how commodity price volatility has a different effect on the external debt depending on which exchange rate regime is in place. We use the most recent data available up to 2016 to captures the effects of the recent GFC and the European sovereign debt crisis. Therefore, this study will be a valuable addition to the existing literature.

3.3. The movement of commodity price volatility and external debt

In this section, we discuss the movement of commodity price volatility and external debt over time. The primary axis, left-hand side (LHS), in Figure 3.1 shows the movement of external debt for all three country groups. On the secondary axis, right-hand side (RHS), we present the movement of commodity price volatility. From the RHS of Figure 3.1, it is observed that from the early-1990s to the mid–2000s, commodity price volatility was low, reflecting the period referred to as the 'Great Moderation'.[26] In 2007–2009 (i.e., during the GFC), a big spike was observed in commodity price volatility. The period after 2009 shows greater volatility than the pre-GFC periods.

Figure 3.1: Movement of commodity price volatility and external debt



Source: Author's calculation based on WB (2018) and IMF (2018) data.

The LHS of Figure 3.1 presents the trend of external debt for the three country groups, all of which have a similar trend, though the external debt is higher in commodity-exporting

[26] The term 'Great Moderation' refers to a reduction in the volatility of business cycle fluctuations starting in the mid–1980s. Bernanke (2004) hypothesise three potential causes for this economic stability: structural change in the economy, improved economic policy and good luck.

countries.[27] We also observe that during the 1980s, external debt increased continuously. The period of high debt in the 1980s is known as the 'Washinton Consensus': countries were under pressure to implement major policy reforms, such as opening their economies to increased trade, privatising state-owned firms and seeking foreign investment. The reforms were often imposed on developing countries as a condition for debt relief and financial support from Washington DC-based institutions, namely, the United States Treasury, the IMF and the WB.

A striking feature of Figure 3.1 shows that during the Great Moderation period (low commodity price volatility), the external debt declines substantially, particularly in commodity-exporting countries. After 2008, commodity price volatility increases significantly in line with external debt increases.

3.4. Theoretical background

The impact of external shocks under different exchange rate regimes can be analysed by the movement of investment-savings (IS) curves that describes how the goods and money markets interact to balance the economy's interest rate and output. We can explain the impact of commodity price volatility in an open economy under a fixed exchange rate and a floating exchange rate regime by using the movement of IS curve.

3.4.1. Commodity price volatility shocks in commodity-exporting countries under the floating and fixed exchange rate regimes

We can explain the mechanism of commodity price volatility shocks in commodity-exporting countries under the floating and fixed exchange rate using investment-savings (IS) diagrams, as shown in Figures 3.2a and 3.2b.

[27] We use the average of external debt data in Figure 3.1.

Figure 3.2a. Shocks with floating exchange rate

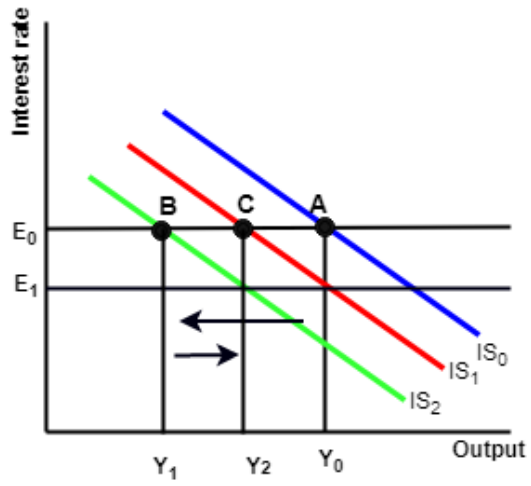


Figure 3.2b. Shocks with fixed exchange rate

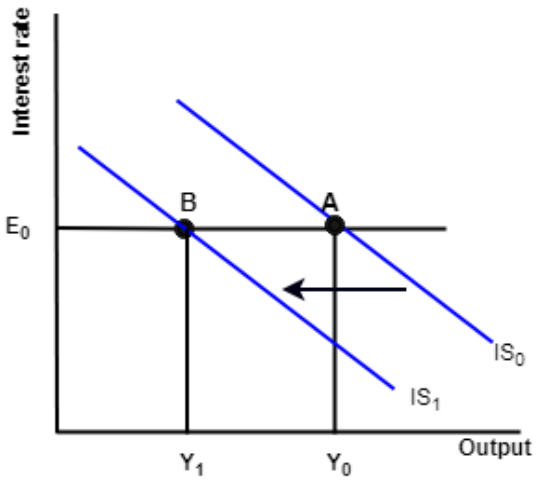


Figure 3.2a shows the effects of commodity price volatility under a floating exchange rate regime. Starting from the initial equilibrium point A where initial output is Y_0. Commodity price volatility decreases investment due to the macroeconomic uncertainty.[28] As a result, the initial IS_0 curve shifts to the left at IS_2. The new equilibrium point is B, where the output is Y_1, which is lower than the previous output level at point A (Y_0). At point B, the interest rate falls and could be lower than the world interest rate, causing capital outflow, leading to the depreciation of the currency under the floating exchange rate regime. As the currency depreciates, export expands and import falls, causing output start to rise again and the IS curve shifts towards its new equilibrium point at C. Therefore, floating exchange rate helps to recover the economy from the external shocks and therefore, country's current account balance increases and external debt decreases.

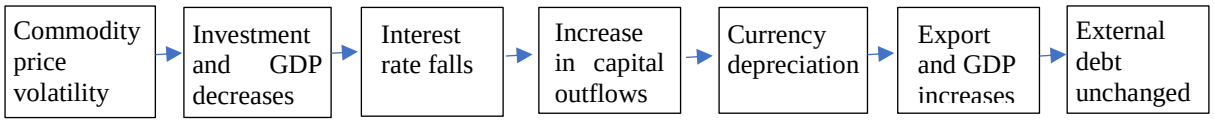
In contrast, Figure 3.2b shows the effects of commodity price volatility in the economy under a fixed exchange rate regime. The initial equilibrium point is A, where the country's equilibrium output is Y_0. The commodity price volatility causes decreases in investment and

[28] Note that commodity price volatility in a commodity exporting country may lead to uncertainty for investors in all sectors related to commodities.

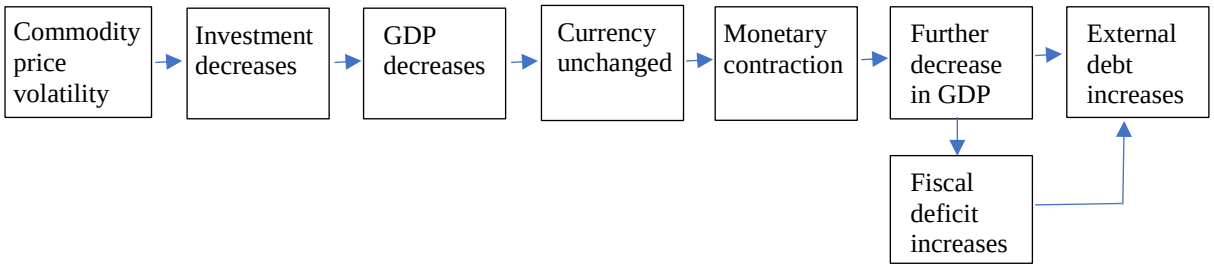
output and therefore, the IS_0 curve shifts to the left as IS_1. The new equilibrium point is B, where the output is Y_1, which is lower than the previous equilibrium point A (Y_0). Under the fixed exchange rate regime, the CB purchases the domestic currency to keep its value unchanged. As a result, the domestic money supply decreases. This monetary contraction results in a further decrease in output. Therefore, from the above two figures we can observe that the reduction in output is smaller under a floating exchange rate regime (Figure 3.2a) than a fixed exchange rate regime (Figure 3.2b) meaning that commodity price volatility causes to rise external debt more with a fixed exchange rate regime. In Figure 3.3, we show the flowchart of this theoretical explanation.

Figure 3.3: Commodity price volatility and external debt

a. Under a floating exchange rate regime



b. Under a fixed exchange rate regime



3.5. Methodology

To explore the impact of commodity price volatility on external debt, we employ the three dynamic panel data estimation models discussed in Chapter 2: pooled OLS, FE and RE.[29] To select the appropriate model from FE and RE models, we use the Hausman test. Based on the

[29] We do not use period fixed effect models, period random effect models and combine effects (both cross-section and period fixed) models because commodity price data are fixed in cross-section levels.

result of the Hausman test, we use the FE model as our baseline model as described in this section.[30]

3.5.1. Fixed-effect (FE) model

As discussed in Section 2.3.1, the FE model captures all effects that are specific to a particular country and that remain constant, thus controlling unobserved heterogeneity when it is constant over time and correlated with the independent variables. The FE model assumes that these unobservable factors may affect the predictor or outcome variable and thus, controls for this are necessary. The model removes the effect of time-invariant characteristics to allow assessment of the net impact of commodity price volatility on external debt accumulation. We estimate the following model:

$$PCED_{i,t} = \beta_{0i} + \beta_1 PCED_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 RIR_{i,t} + \beta_5 FDI_{i,t} + \beta_6 CAB_{i,t}$$

$$+\beta_7 GDP_{i,t} + \varepsilon_{i,t} \quad (3.1)$$

where β_{0i} is the unobserved time-invariant individual effect. $PCED_{i,t}$ is the percentage change in external debt (% of GNI); $PCED_{i,t-1}$ represents the lag in the percentage change in external debt (% of GNI); $CPV_{i,t}$ indicates the commodity price volatility, while $PCCP_{i,t}$ represents the percentage change in commodity prices. $RIR_{i,t}, FDI_{i,t}$, $CAB_{i,t}$ and $GDP_{i,t}$ represent the real interest rate (annual %), foreign direct investment (% of GDP), current account balance (% of GDP), and GDP per capita growth (annual %) respectively.

Change in external debt ($PCED_{i,t}$): Change in external debt is our dependent variable and is denoted by $PCED_{i,t}$ in the model. We use debt as a measure of fiscal policy because it is a broader measurement of government fiscal activities than the budget deficit. The commonly reported measures of financial balance overstate the economically relevant deficit

[30] Results for the Hausman test are presented in Appendix Table A 3.7 in Appendix 3.2.

by including the inflation component of interest payments on the government debt. It would be more appropriate, however, if the interest component of government debt was treated as a type of debt repayment rather than as an item of current budgetary expenditure. The change in government debt automatically adjusts this component (Roubini & Sachs 1989).

Lagged change in external debt ($PCED_{i,t-1}$): We include the lagged value of external debt as an influencing variable to correct for past budgetary imbalances. A significant change in fiscal policy in the past may induce governments to undo part of the recent increases. Changes in the government debt may also result from lags or delays in effecting budgetary initiatives, for example, previous fiscal policy decisions, such as the implementation of tax reforms and significant spending reforms, can affect public finances in the following years. Therefore, it is expected a positive sign (+) in this variable.

Commodity price volatility($CPV_{i,t}$): Generally, primary commodity prices are more volatile than the prices of manufacturing goods. Following the recent global financial crisis (GFC) in 2007-2009, commodity price volatility increased, considerably (Omojolaibi & Egwaikhide 2014). Because of this volatility, government revenue tends to be more volatile – along with government spending. The uncertainty of future revenue from commodities and the variability of those revenues results in changes in the expenses as the government reassesses its expected revenue stream, generating significant adjustment costs. In these circumstances, governments try to borrow from external sources to smooth out the level of economic activities. As a result, it can generally be expected that commodity price volatility will increase government external debt. We expect a positive (+) sign in this variable.

Change in commodity prices ($PCCP_{i,t}$): It is expected that external debt will decrease with the increase in commodity prices and vice-versa. Governments can repay the debt by using

extra revenue accrued from the commodity price windfall, especially in the commodity-exporting countries. Therefore, it is expected a negative (-) sign of this variable.

Real interest rate ($RIR_{i,t}$): The interest rate is the price a borrower pays for the use of the money they borrow from a lender/financial institution or the fee paid on borrowed assets (Crowley 2007). It is expected that external debt increases with an increase in real interest rates because more money is needed to pay to the lenders. We expect a positive (+) sign for this variable.

Foreign direct investment ($FDI_{i,t}$): It is expected that an increase in FDI rate promotes economic growth that helps to reduce external debt accumulation. According to Borensztein, De Gregorio and Lee (1998), FDI is an important vehicle for the transfer of technologies, knowledge and human capital, all associated with higher productivity and eventually decrease external debt. Therefore, the sign will be negative (-).

Current account balance ($CAB_{i,t}$): It is expected that the current account balance has a negative impact on external debt accumulation. If a country's balance increases indicating that its exports are more than imports. This encourages investment and output growth causing lower external debt and vice-versa. Mehta and Kayumi (2014) show there is a negative relationship between current account balance and external debt in India. We expect a negative (-) sign in this variable.

Gross domestic product ($GDP_{i,t}$): It is expected that external debt decreases with the increase in GDP per capita. This is because with the higher per capita income people will pay more taxes than increase the government's tax revenue and also decreases the government's expenses in the form of social benefits. Therefore, we expect a negative (-) sign in this variable.

The subscripts *i* and *t* denote the country and period, respectively. The idiosyncratic disturbance term is denoted by $\varepsilon_{i,t}$. By using lag dependent variable, we capture the

autocorrelation in the model. As in Chapter 2, equation (3.1) uses estimates for the different groups of countries (i.e., full sample, commodity-exporting and commodity-importing countries) to examine the hypothesis that the impact of commodity price volatility on external debt differs with the level of commodity endowments.

3.6. Data and description of the variables

3.6.1. The data

To estimate the models, this study employs an unbalanced annual panel data dataset for 97 countries covering the period from 1993 to 2016.[31] The countries and period are included based on data availability. The data for external debt, foreign direct investment, real interest rate, current account balance and GDP per capita growth are collected from the WDI of the WB.

The data for commodity prices are obtained from the IMF primary commodity price sheet. We convert the data into the annual form by taking the average of monthly data. Commodity prices are expressed as an index using the 2005 base price and include both fuel and non-fuel price indices. We estimate commodity price volatility from the commodity price index using the standard deviation from monthly data to capture monthly price variation.[32] Volatility is the degree of variation of a trading price series over time. Commodity price volatility for each year is calculated by using standard deviation,

$$\sigma_t = \sqrt{\sum_{\tau=1}^{12} \frac{(P_\tau - \mu_t)^2}{12-1}} \tag{3.2}$$

where, σ_t = commodity prices volatility at time *t*, P_τ = observed monthly prices, μ_t = average price ($\mu_t = (1/12) \sum_{\tau=1}^{12} P_\tau$) , and τ = months (1, 2, 3 … 12)

[31] List of full sample (97) and commodity-exporting and importing countries are presented in Tables A 3.2 and A 3.3 in Appendix 3.1, respectively.
[32] For example, with monthly data, the commodity price volatility in 2016 is computed as the commodity price volatility over the period from 2016:1 to 2016:12.

We estimate the commodity price changes as follows:

$$PCCP_t = \frac{P_{t2} - P_{t1}}{P_{t1}} X\ 100 \quad (3.3)$$

where $PCCP_t$= percentage changes in commodity prices, P_{t1} = commodity prices at time t_1 and P_{t2} = commodity prices at time t_2. By using a similar equation of 3.3, we estimate percentage change in external debt.

3.6.2. Unit root test, descriptive statistics and correlation matrix

We estimate the unit root to test the stationary properties for all variables using the ADF and PP tests. With the exception of external debt and commodity prices, all variables included in the model are stationary at ρ = 0.05. The ρ-values of external debt and commodity prices are > 0.05, indicating that these two series are not stationary. To make these series stationary, we use the percentage change of these two series. The results for unit root test, descriptive statistics and correlation matrix are presented in Tables A 3.4, A 3.5 and A 3.6 in Appendix 3.1.

3.7. Empirical results

In this section, we describe the estimated coefficients for all countries in the sample, and those of commodity-exporting and commodity-importing countries, estimated with the cross-section FE model. The result of the Hausman test indicates that the FE model is the most appropriate choice for this study.[33]

3.7.1. Results for different country groups (full sample, commodity-exporting and commodity-importing countries)

In this section, we only discuss the coefficient of the variables of interest: commodity price volatility and commodity price changes. The coefficients of other control variables are

[33] Description of pooled OLS and RE are presented in Appendix 3.2.

consistent with literature. Table 3.2 shows the results for full sample and columns 1, 2 and 3 represent the pooled OLS, FE and RE models, respectively. The coefficient of the commodity price volatility is positive (0.17, see column 2), indicating that change in external debt increases with commodity price volatility in all countries in the sample. All things being equal, a one standard deviation increase in commodity price volatility leads to growth in external debt of 0.17 units as a share of GNI. Simultaneously, the negative coefficient of commodity price changes (–0.24, see column 2) indicates that growth in external debt falls with the increase in commodity prices. A one-unit increase in commodity prices is associated with a significant decrease in the change in external debt by 0.24 units. The results are consistent across all three panel data estimation models and are significant at the 1% level.

Table 3.2: Determinants of the external debt (full sample)

	Dependent variable: $PCED_{i,t}$		
	pooled OLS	FE	RE
	(1)	(2)	(3)
$PCED_{i,t-1}$	0.09***	0.03***	0.09***
	(0.01)	(0.01)	(0.01)
	[0.02]	[0.02]	[0.02]
$CPV_{i,t}$	0.16**	0.17**	0.16**
	(0.07)	(0.07)	(0.07)
	[0.09]	[0.10]	[0.09]
$PCCP_{i,t}$	–0.28***	–0.24***	–0.28***
	(0.03)	(0.03)	(0.03)
	[0.03]	[0.03]	[0.03]
$RIR_{i,t}$	0.18***	0.25***	0.18***
	(0.05)	(0.06)	(0.05)
	[0.08]	[0.09]	[0.08]
$FDI_{i,t}$	0.05	−0.02	0.05
	(0.11)	(0.14)	(0.11)
	[0.14]	[0.16]	[0.14]
$CAB_{i,t}$	−0.12*	−0.50***	−0.12*
	(0.07)	(0.09)	(0.07)
	[0.14]	[0.16]	[0.14]
$GDP_{i,t}$	−1.04***	−1.51***	−1.04***
	(0.14)	(0.16)	(0.14)
	[0.14]	[0.16]	[0.14]
R^2	0.12	0.21	0.12
Adjusted R^2	0.12	0.16	0.12
Periods	24	24	24
Countries	97	97	97
Observations	1653	1653	1653

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets for robustness.

Table 3.3 shows the empirical findings of the effects of commodity price volatility in the growth of external debt in commodity-exporting and commodity-importing countries. The coefficient of the commodity price volatility is positive (0.32) and higher than the full sample, meaning that commodity price volatility has a larger effect in the commodity-exporting countries' external debt accumulation (see column 2 in Table 3.3). This is because in commodity-exporting countries, commodity-linked revenues constitute a significant share of the government's revenues. Conversely, commodity price volatility does not show any statistically significant impact on external debt in commodity-importing countries (see columns

4, 5 and 6). This result is consistent with the view of Cavalcanti, Mohaddes and Raissi (2012) that commodity-importing countries have highly diversified commodity export and import baskets. Thus, these countries are not fully dependent on commodity revenues and volatility in commodity prices has less or no effect on those countries compared to commodity-exporting countries.

Table 3.3 also shows a negative nexus between change in commodity prices and growth in external debt, indicating that external debt accumulation significantly decreases with increases in commodity prices in commodity-exporting countries (see columns 1, 2 and 3). Exporting countries may repay their external loans by windfall revenues from commodity price booms. This result is supported by Swaray (2005), who finds a negative relationship between government debt and commodity prices in exporting countries.

Our empirical results also show that external debt decreases with the increase in commodity prices in commodity-importing countries. This result contradicts the twin-deficit hypothesis, which states that current account deficits (when import increases above export) cause fiscal deficits (expenses exceed revenues). One of the plausible reasons for this negative link between commodity price changes and external debt is importing countries collect more revenue by imposing high taxes on commodities. For example, in the Organisation for Economic Co-operation and Development (OECD) countries, the average oil import tax is 51.3% per litre.

Table 3.3: Determinants of the external debt (commodity-exporting and importing countries)

	Dependent variable: $PCED_{i,t}$					
	Commodity-exporting countries			Commodity-importing countries		
	pooled OLS (1)	FE (2)	RE (3)	pooled OLS (4)	FE (5)	RE (6)
$PCED_{i,t-1}$	0.09***	0.03	0.09***	0.09***	0.03*	0.09***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.04]	[0.04]	[0.02]	[0.02]	[0.02]
$CPV_{i,t}$	0.32**	0.32**	0.32**	0.05	0.07	0.05
	(0.13)	(0.13)	(0.13)	(0.08)	(0.08)	(0.08)
	[0.21]	[0.21]	[0.21]	[0.07]	[0.08]	[0.07]
$PCCP_{i,t}$	–0.33***	–0.29***	–0.33***	–0.24***	–0.21***	–0.24***
	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
	[0.06]	[0.06]	[0.06]	[0.04]	[0.04]	[0.04]
$RIR_{i,t}$	0.21	0.22**	0.21	0.18***	0.27***	0.18***
	(0.10)	(0.12)	(0.10)	(0.06)	(0.07)	(0.06)
	[0.13]	[0.16]	[0.13]	[0.10]	[0.12]	[0.10]
$FDI_{i,t}$	0.26	−0.006	0.26	−0.04	−0.04**	−0.04
	(0.25)	(0.31)	(0.25)	(0.12)	(0. 15)	(0.12)
	[0.24]	[0.27]	[0.24]	[0.15]	[0.18]	[0.15]
$CAB_{i,t}$	−0.10	−0.50***	−0.10	−0.14*	−0.50***	−0.14*
	(0.13)	(0.18)	(0.13)	(0.07)	(0.11)	(0.07)
	[0.14]	[0.16]	[0.14]	[0.14]	[0.16]	[0.14]
$GDP_{i,t}$	−1.49***	−1.84***	−1.49***	−0.84***	−1.27***	−0.84***
	(0.25)	(0.27)	(0.25)	(0.17)	(0.19)	(0.17)
	[0.14]	[0.16]	[0.14]	[0.14]	[0.16]	[0.14]
R^2	0.13	0.20	0.13	0.12	0.24	0.12
Adjusted R^2	0.12	0.14	0.12	0.12	0.18	0.12
Periods	24	24	24	24	24	24
Countries	41	41	41	56	56	56
Observations	698	698	698	955	955	955

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

In general, it is argued that external debt accumulation significantly increases with commodity price volatility in all countries in the sample and commodity-exporting countries. However, this impact is not statistically significant in commodity-importing countries. Additionally, our empirical results show that external debt decreases with the increase in commodity prices in all country groups.

3.7.2. Results for different country groups with alternative exchange rate regimes

In this section, we discuss the impact of commodity price volatility on external debt with alternative exchange rate regimes in line with the theoretical framework described in Section 3.4. In Table 3.4, we present the empirical results for full sample, and we observe that the coefficient of commodity price volatility is statistically significant in both fixed exchange rate (column 1) and managed floating exchange rate regimes (column 2) though impact is higher in case of fixed regimes (0.34) compared to managed foalting regime (0.32). However, we do not find any statistically significant impact of commodity price volatility on external debt growth under a floating exchange rate regime. These empirical findings support our theoretical description presented in Section 3.4 where Figure 3.2a shows that commodity price volatility has no impact on external debt under a floating exchange regime, and Figure 3.2b demonstrates that commodity price volatility causes higher external debt under a fixed exchange rate regime. Therefore, our empirical findings indicate that the impact of commodity price volatility on external debt decreases with exchange rate flexibilities.

Table 3.4: Determinants of the external debt in the full sample (based on exchange rate regimes)

	Dependent variable: $PCED_{i,t}$		
	Fixed exchange rate	Managed floating exchange rate	Floating exchange rate
	(1)	(2)	(3)
$PCED_{i,t-1}$	–0.13**	0.05	0.02
	(0.06)	(0.03)	(0.04)
	[0.05]	[0.03]	[0.03]
$CPV_{i,t}$	0. 34*	0.32***	–0.06
	(0.19)	(0.09)	(0.47)
	[0.43]	[0.10]	[0.33]
$PCCP_{i,t}$	–0.25***	–0.32***	–0.06
	(0.09)	(0.05)	(0.20)
	[0.08]	[0.08]	[0.20]
$RIR_{i,t}$	0.08	0.39***	0.21
	(0.23)	(0.11)	(0.21)
	[0.16]	[0.15]	[0.29]
$FDI_{i,t}$	–0.39	–0.35	-0.18
	(0.39)	(0.26)	(1.01)
	[0.31]	[0.31]	[0.89]
$CAB_{i,t}$	–0.56**	–0.68***	0.59
	(0.22)	(0.17)	(0.72)
	[0.16]	[0.24]	[0.54]
$GDP_{i,t}$	–0.34	–1.42***	–2.00**
	(0.45)	(0.25)	(0.86)
	[0.35]	[0.38]	[1.16]
R^2	0.20	0.28	0.71
Adjusted R^2	0.08	0.20	0.56
Periods	18	18	18
Countries	31	67	27
Observations	281	743	100

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

Table 3.5 shows the results for the impact of commodity price volatility on external debt in commodity-exporting countries under three different exchange rate regimes. The coefficient of commodity price volatility is higher than the full sample (see Table 3.4) under both the fixed and managed floating exchange rate regimes, indicating that commodity-exporting countries are more sensitive to commodity price volatility under both regimes. From the Table 3.5, we also observe that the coefficient of commodity price volatility is three times higher in a fixed exchange rate regime (1.21) compared with a managed floating exchange rate

regime (0.37). In contrast, we do not find any statistically significant impact of commodity price volatility under a floating exchange rate regime.

Table 3.5: Determinants of external debt in commodity-exporting countries

	Dependent variable: $PCED_{i,t}$		
	Fixed exchange rate	Managed floating exchange rate	Floating exchange rate
	(1)	(2)	(3)
$PCED_{i,t-1}$	−0.10	0.06	–0.32
	(0.10)	(0.04)	(0.25)
	[0.09]	[0.05]	[0.30]
$CPV_{i,t}$	1.21**	0.37**	3.10
	(0.46)	(0.15)	(2.85)
	[1.25]	[0.15]	[0.86]
$PCCP_{i,t}$	–0.41*	–0.30***	–0.28
	(0.23)	(0.08)	(0.56)
	[0.09]	[0.09]	[0.46]
$RIR_{i,t}$	−0.09	0.33***	−0.23
	(0.38)	(0.15)	(0.60)
	[0.34]	[0.19]	[0.32]
$FDI_{i,t}$	–0.08	–0.27	−5.35
	(0.96)	(0.55)	(5.36)
	[0.75]	[0.45]	[4.51]
$CAB_{i,t}$	–0.86*	–0.86***	1.10
	(0.45)	(0.28)	(1.31)
	[0.28]	[0.53]	[0.64]
$GDP_{i,t}$	0.36	–1.89***	–3.50**
	(0.95)	(0.40)	(1.38)
	[0.66]	[0.78]	[1.86]
R^2	0.24	0.27	0.90
Adjusted R^2	0.07	0.19	0.74
Periods	18	18	15
Countries	14	30	12
Observations	111	350	30

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

In Table 3.6, we present the role of alternative exchange rate regimes to examine the impact of commodity price volatility on external debt in commodity-importing countries. The empirical results show that commodity price volatility on growth in external debt increases in managed floating exchange rate regime. However, we do not find any statistically significant impact under a floating exchange rate regime or under the fixed exchange rate regime, which is somewhat anomalous.

Table 3.6: Determinants of external debt in commodity-importing countries

	Dependent variable: $PCED_{i,t}$		
	Fixed exchange rate	Managed floating exchange rate	Floating exchange rate
	(1)	(2)	(3)
$PCED_{i,t-1}$	–0.28***	0.04	0.06
	(0.07)	(0.04)	(0.05)
	[0.10]	[0.06]	[0.18]
$CPV_{i,t}$	–0.09	0.30**	–0.28
	(0.15)	(0.13)	(0.48)
	[0.15]	[0.15]	[0.95]
$PCCP_{i,t}$	–0.12	–0.34***	0.03
	(0.07)	(0.07)	(0.22)
	[0.08]	[0.06]	[0.31]
$RIR_{i,t}$	0.58*	0.45**	0.15
	(0.30)	(0.17)	(0.22)
	[0.18]	[0.16]	[0.14]
$FDI_{i,t}$	–0.17	–0.31	−0.41
	(0.32)	(0.31)	(1.05)
	[0.29]	[0.33]	[2.01]
$CAB_{i,t}$	–0.32	–0.58***	–0.90
	(0.20)	(0.22)	(1.41)
	[0.21]	[0.25]	[1.87]
$GDP_{i,t}$	−0.59	−1.08***	−0.66
	(0.38)	(0.33)	(1.35)
	[0.35]	[0.35]	[1.35]
R^2	0.31	0.28	0.50
Adjusted R^2	0.20	0.19	0.19
Periods	18	18	18
Countries	17	37	15
Observations	170	393	70

Note: Standard errors are presented below the corresponding coefficients in brackets. The asterisks ***, ** and * indicate the significance at the 1%, 5% and 10% level, respectively. Cluster standard errors are presented in square brackets.

3.8. Conclusion

This study aimed to explore the impact of commodity price volatility on external debt accumulation. Using dynamic panel data models for 97 countries for the period from 1993 to 2016, this study found that external debt increases with commodity price volatility. Our empirical findings show that commodity price volatility has a significant adverse effect on external debt accumulation in the full sample and commodity-exporting countries. However, we do not find any statistically significant impact in commodity-importing countries.

This study also examines the impact of commodity price volatility in three different exchange rate regimes: fixed, managed floating and freely floating. Once the exchange rate is freely determined by market (floating exchange rate), the impact of commodity price volatility on external debt is statistically insignificant. When the exchange rate is completely fixed, compared to a managed floating exchange rate, the impact is three times higher in commodity-exporting countries. Based on these results, we can conclude that the adoption of exchange rate regimes determined by markets (freely floating exchange rate regime) is critical to reduce the adverse impact of commodity price volatility on external debt especially in commodity-exporting countries.

There are several possible avenues for investigation to extend this study. For example, future work may focus on the role of capital flows in the relationship between commodity price volatility and external debt. This extension may illuminate the mechanism of this relationship.

Chapter 4

Oil Curse, Economic Growth and Trade Openness

4.1. Introduction

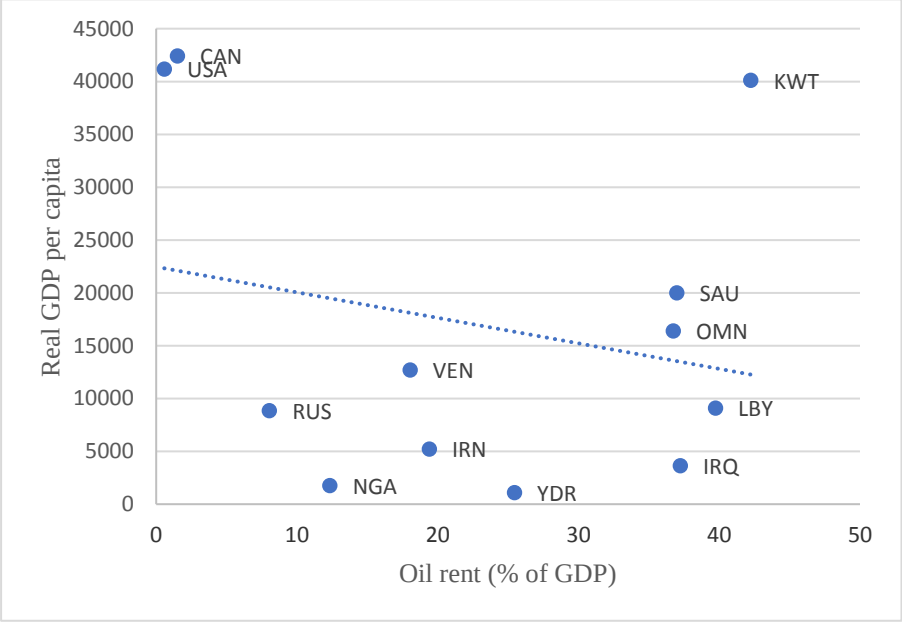
The conventional intuition is that natural resources help to increase a country's economic growth and development. Contrary to this, the literature reports that countries rich in natural resources tend to have lower real GDP per capita than resource-poor countries—this paradox is known as the 'resource curse' [see, e.g., Van der Ploeg (2011), Gylfason (2000), Sachs and Warner (1995), and Auty (1993)].[34] For example, oil-rich countries such as Venezuela, Nigeria and the Republic of the Congo are poor in terms of real GDP per capita, while some resource-poor countries such as Singapore, South Korea and Hong Kong have very high real GDP per capita.[35] The literature identifies several factors that explain this paradox such as poor institutional quality, political rent-seeking, commodity price volatility and lack of diversification. However, several other factors remain unexplored. This study examines a country's trade openness as a channel that may influence the resource curse.[36] The idea that trade openness increases economic growth is well known; however the role of trade openness in reducing the resource curse is yet to be explored.

Trade openness increases real GDP per capita in a resource-rich country in different ways. Our hypothesis is that increased trade helps to lessen the resource curse problem by reallocating resources more efficiently. It provides countries access to the international market and higher prices for their products. This access to international prices increases the country's income and real GDP per capita. Trade openness also makes available opportunities to use

[34] The term 'resource curse' was first coined by Auty (1993) to explain the negative relationship between resource dependency and economic growth.
[35] Note that this is not true for all countries. For example, oil-rich countries such as Norway, Saudi Arabia and Qatar have high GDP per capita.
[36] Trade openness is the sum of export and import of the goods and services measured as a percentage of GDP.

advanced technologies for more efficient extraction of natural resources. With the use of new technologies, natural resource–rich countries can produce intermediate and final goods from primary goods and earn more profits. Trade openness helps to modernise the full economy by improving other related sectors such as roads and transport systems (Pedersen 2000), financial sectors (Braun & Raddatz 2008) and bureaucratic systems (Dutt 2009). Overall, trade openness plays a crucial role in converting natural resources into a blessing rather a curse. Figure 4.1 shows the relationship between real GDP per capita and oil rent (% of GDP) for the period 1980–2017.

Figure 4.1: Relation between real GDP per capita and oil rent (% of GDP) in countries with higher oil reserves.



Source: Author's calculations based on WB (2019) data.

Despite the positive impact of trade openness on economic growth and development, it was not considered comprehensively when studying the resource curse, aside from a brief discussion in a few studies.[37] Arezki and Van der Ploeg (2011) investigate the role of trade and institutions in reducing the resource curse and find that the resource curse becomes weaker in

[37] Throughout this study, we use change in real GDP per capita and economic growth interchangeably.

countries with a high degree of trade openness. In their seminal study, Sachs and Warner (1995) also find that trade openness improves economic growth by reducing the resource curse. However, these studies are based on cross-section growth models where the average growth over recent decades is regressed on a measure of resource abundance and a selection of control variables.

In this study, we use a dynamic panel data framework to investigate the impact of trade openness on the resource curse.[38] To the best of our knowledge, this is the first study to explore the relationship between the resource curse and trade openness in a dynamic panel data framework (rather than cross-sectional long-term perspective).[39]

This study uses an unbalanced dynamic panel data model that covers 95 countries for the period 1980–2017. Countries and periods are based on data availability from the WB and IMF. We use the data for the full sample period (1980–2017) and also provide estimations splitting the sample period into two subsample periods: 1980–1994 (before the WTO) and 1995–2017 (after the WTO). We assume that the commencement of the WTO in 1995 contributed to significant increases in international trade and that increased trade helps to lessen the resource curse by more efficiently reallocating resources. Moreover, many countries reduced their trade tariffs under the WTO agreements which has helped to boost international trade during the last two decades.[40] For example, China abolished non-tariff barriers and reduced tariffs in the manufacturing sector after it joined the WTO in 2001. This significantly

[38] Panel data usually gives researchers a large number of data points, increasing the degrees of freedom and reducing the collinearity among explanatory variables, thus improving the efficiency of econometric estimates (Hsiao 2014). Moreover, the combined panel data matrix set consists of a time series for each cross-sectional member in the data set and offer a variety of estimation methods (Asteriou & Hall 2015).

[39] Few studies use panel data models to discuss the resource curse hypothesis. By using a panel data model consisting of 56 countries from 1972–2000, Mavrotas, Murshed and Torres (2011) found that point resource dependence harms economic growth in developing countries.

[40] The WTO is an intergovernmental organisation that deals with the regulation of trade in goods, services and intellectual property between participating countries by providing a framework for negotiating trade agreements and a dispute resolution process. Subramanian and Wei (2007) argue that the WTO contributed to 120 per cent more trade in 2000, valued about US$8 trillion.

increased the demand for metals such as copper, aluminium, and steel (Coates & Luu 2012). This increased demand probably had an exogenous impact on the growth of other countries. For example, Andersen et al. (2014) empirically found that China's accession to the WTO contributed to improving the growth rate in sub-Saharan African countries.

This study focuses on oil as a natural resource because it is a highly tradeable commodity. As oil price is directly linked to the production process, it may have a significant impact on inflation, employment and output (Guo & Kliesen 2005). Moreover, point-source resources such as oil are more prone to rent-seeking that leads to resource curse (Boschini, Pettersson & Roine 2007, and Isham et al. 2005).[41] In this study, we use oil rent (% of GDP) as a measure of natural resource abundance.[42] Although our study finds the existence of the resource curse, trade openness significantly decreases the resource curse problem, especially after the introduction of the WTO.

This study contributes to the literature in the following ways. First, to the best of our knowledge, no previous studies have examined trade openness as a transmission channel for reducing the resource curse by using dynamic panel data models. Second, using panel data allows us to evaluate the effect of trade openness over time and, particularly, the impact of the dramatic changes that followed the commencement of the WTO. Finally, the time dimension of the panel data allows us to include periods of important recent fluctuations such as the global financial crisis and European sovereign debt crisis.

[41] A point-source resource is a resource concentrated in a single identifiable location (i.e., not diffused in wide areas).

[42] Following Bjorvatn, Farzanegan and Schneider (2012); Arezki and Brückner (2011); Bhattacharyya and Hodler (2010); and Collier and Hoeffler (2005), we use oil rents (% of GDP) as a proxy of natural resource abundance. Rents are basically net profits from resource extraction, defined as the value of the product minus total cost of production. Rents measure the value of natural resources for a country. More precisely, they provide a less ambiguous measure of resource dependence compared with those previously used such as primary commodity exports, oil exports and reserves. The rent data tells us the value of the resource in the open market relative to the productivity of the economy, and, indirectly, the value of capturing them (De Soysa & Neumayer 2007). For robustness, we use the natural resource rent (% of GDP). We define 'abundance' as the resource contributing a large share of a country's GDP.

The study proceeds as follows. Section 4.2 provides an overview of the resource curse literature. Section 4.3 describes the conceptual framework of the importance of trade. The methodology of this study is described in Section 4.4. Section 4.5 describes the data and description of the variables and Section 4.6 presents the empirical results from panel data estimations. Section 4.7 provides our conclusions and directions for future studies.

4.2. Overview of the resource curse literature

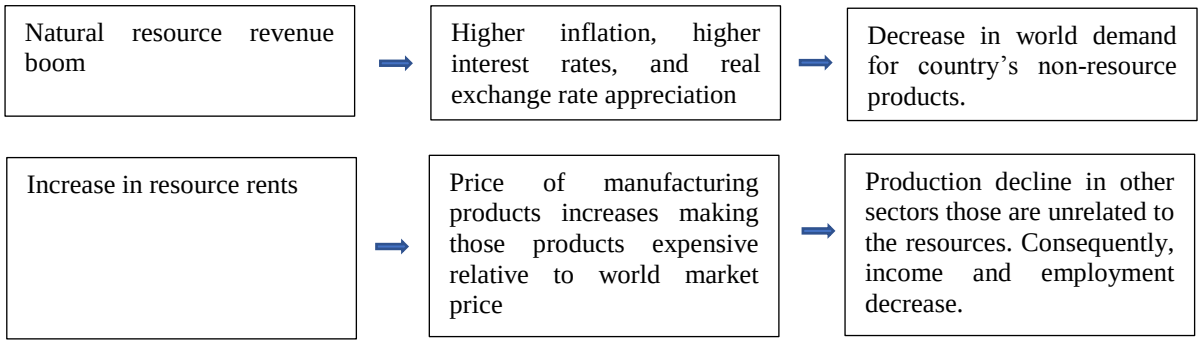
To study the role of natural resources in economic growth, it is essential to investigate the mechanisms that link endowments of natural resources to poor economic performance. In the literature, various economic and political reasons have been discussed for the failure to transform natural resources into economic growth including the 'Dutch disease', political rent-seeking and corruption, poor institutional quality, commodity price volatility and lack of diversification. We discuss these factors in detail in the following sections.

4.2.1. The Dutch disease

One of the most common economic reasons suggested for the resource curse is popularly known as the Dutch disease. In most resource-rich countries, sectors other than resources are likely to suffer from a real appreciation of the national currency due to natural resource earnings, in part, being absorbed by the domestic non-tradeable sectors [see, e.g., Papyrakis and Gerlagh (2007), Iimi (2007), Sachs and Warner (1995), and Corden and Neary (1982)].[43] This results in exports from the non-resources sectors (usually manufacturing) become more expensive relative to the world market, thus making those sectors less competitive. Consequently, total national income is reduced, ultimately causing economic growth to slow. This mechanism is known as the 'spending effect' (see Figure 4.2).

[43] Corden (1984) and Corden and Neary (1982) first developed the Dutch disease model. Iimi (2007) described Dutch disease as the most prominent channel of the resource curse. Sachs and Warner (1995) argued that the Dutch disease is responsible for the slow economic growth of resource-rich African countries.

Figure 4.2: The spending effect in the 'Dutch disease'



Source: Badeeb, Lean and Clark (2017).

4.2.2. Political rent-seeking and corruption

According to Deacon and Rode (2015), Hodler (2006), Lam and Wantchekon (2003), and Gylfason (2001) the powerful political elites of resource-rich countries can control revenues from natural resources. These elites tend to distribute the windfall revenues for the benefit of their own existing business and personal networks, instead of investing them in the development sectors. This rent-seeking behaviour increases income inequality which hampers sustainable economic growth. Moreover, such revenue windfalls are considered to be one of the major reasons for the increasing conflict between stakeholders such as taxpayers, politicians, local tribes and developers (Sala-i-Martin & Subramanian 2013). Such conflict discourages both domestic and international investment which also leads to lower economic growth.

4.2.3. Poor institutional quality

Another reason for the resource curse—and closely related to political rent-seeking—is poor institutional quality. According to Mavrotas, Murshed and Torres (2011) and Mehlum, Moene and Torvik (2006), a country's institutional quality plays an important role in determining whether an abundance of natural resources is a blessing or a curse. It is argued that high levels of growth in resource-rich countries are due to the way in which rents from natural resources are distributed through existing institutional arrangements. If institutional quality is good, a generous endowment of natural resource is a blessing. Sarmidi, Hook Law and Jafari (2014),

Torvik (2009), and Mehlum, Moene and Torvik (2006) argue that the adverse effect of natural resource abundance on economic growth will be dissipated if institutional quality is improved.

4.2.4. Commodity price volatility

Commodity price volatility is another important channel for the resource curse. According to the Bellemare, Barrett and Just (2013), Dwyer, Gardner and Williams (2011), Tujula and Wolswijk (2004), and Dehn (2000), commodity price volatility generates uncertainty in the economy, delays stability in the budget, undermines the predictability of economic planning and potentially contributes to lower economic growth. Moreover, Catão and Kapur (2004) argue that during volatile periods countries need more international borrowing to smooth consumption. Moreover, countries in this situation can expect to face stringent constraints on their borrowing capacity since financial markets will not only be aware of the default risk that volatility itself generates but will also be mindful that aggregate consumption and real investment decrease in times of commodity price volatility. These dynamics will likely lead to lower economic growth.[44]

4.2.5. Lack of diversification

Another reason for the resource curse is the lack of economic diversification in countries abundant in natural resources. The major share of export earrings in these countries is generated from just one or a few resources. This leads to economic vulnerability from exogenous shocks and results in slow economic growth (De Ferranti et al. 2002). Moreover, the natural resource sector is generally capital intensive and location specific (Masten & Crocker 1985). Consequently, natural resource development brings few positive externalities to forward and

[44] According to Başkaya, Hülagü and Küçük (2013), Salim and Rafiq (2011), and Guo and Kliesen (2005), consumer demand decreases due to the adoption of a precautionary savings mindset by consumers who are worried and uncertain about future income and unemployment levels as they are fearful that these levels may be adversely impacted during a period of commodity price volatility. Consequently, real investment decreases during periods of price volatility (Masih, Peters & De Mello 2011, Henriques & Sadorsky 2011, Guo & Kliesen 2005, Bredin & Fountas 2005).

backward industries (Sachs & Warner 1995). Therefore, the learning-by-doing effect is not expected to be powerful in these economies.

There is considerable literature on the above-mentioned transmission channels that give rise to the resource curse, but scant discussion about the dynamics associated with trade openness. Therefore, this study, which investigates the role of trade openness using panel data models, brings a new dimension to the resource curse literature.

4.3. Conceptual framework: Importance of trade in resource-rich countries

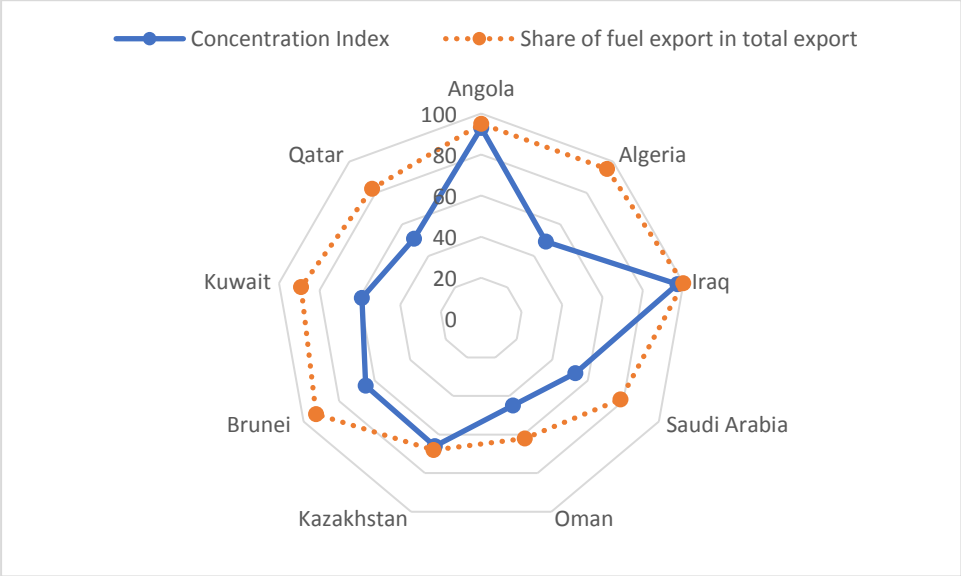
The uneven geographical distribution of resource endowment between countries plays a critically important part in explaining the significance of trade openness. Most of the world's natural resources are concentrated in a relatively small number of countries, while many countries have limited or no natural resources. For example, about 90 per cent of the world's proven oil reserves are in just 13 countries (BP 2017).[45] Consequently, international trade plays a significant role in reducing the disparity in natural resource endowment of countries by allowing resources to move from areas of excess supply to areas of excess demand. Moreover, due to the excessive fixed costs in extracting the resources, large-scale extraction is required to achieve economies of scale. Large-scale production is only beneficial if there is a large market for exports of that resource. Overall, international trade is associated with a more efficient allocation of natural resources that leads to an increase in social welfare (Cho & Diaz 2011).

Another important feature of natural resources is the dominant position of this sector in national economies. Many of resource-rich countries tend to rely on a narrow range of export products. Figure 4.3 shows the value of export product concentration index (PCI) of different

[45] The Middle East countries (Saudi Arabia, Iran, Iraq, Kuwait, Syria, United Arab Emirate, Qatar, Yemen and Oman) contain about 48 per cent of the world's total oil reserve, and Venezuela contains nearly 18 per cent as of 2016. The distribution of other fuels is also concentrated in a very small number of countries. For example, 10 countries possess 80 per cent of global natural gas reserves in 2016, and just nine countries have 90 per cent of the world's coal reserves.

countries along with shares of natural resources in total merchandise exports for selected economies.[46] The PCI is based on the number of products in the Standard International Trade Classification (SITC) at the three-digit level that exceeds 0.3 per cent of a given country's exports collected from the United Nations Conference on Trade and Development (UNCTAD).

Figure 4.3: Dominance of fuel resource exports



Source: Author's calculation based on UNCTAD (2016) and WB (2019).

Figure 4.3 shows that the share of fuel in Kuwait, Brunei, Iraq and Angola is close to 100 per cent of total merchandise exports by 2015. With very few exceptions, countries with a high concentration index also have a high share of fuel resources in their total merchandise exports. The dominance of natural resources in exports follows the hypothesis of comparative advantage theory arguing that countries will specialise in the production of goods where they have a comparative advantage and export them in exchange for other products. This is a direct

[46] The PCI shows to what extent exports and imports of individual countries or country groups are concentrated on several products rather than being distributed homogeneously among products. It is measured as:

$$PCI_j = \sqrt{\frac{\sum_{i=1}^{n}\frac{(x_{i,j})^2}{X_j} - \sqrt{1/n}}{1-\sqrt{1/n}}} \text{x}100$$

where, $x_{i,j}$ is the value of exports of products i from economy j and n is the number of product groups according to SITC, Revision 3, at the three-digit level.

implication of the Heckscher-Ohlin model which proposes that countries export what they can produce.

Overall, the above-described two characteristics of natural resources explain the importance of international trade to the efficient distribution of natural resources. As the government's revenue in resource-rich countries depends on one or few resources, if there are trade barriers then total revenue will decrease, causing slower economic growth. For example, Iran's government revenue and economic growth largely depend on the export of crude oil. However, due to some international restrictions, Iran cannot produce and sell oil at the optimum level and, thus, is forced to sell in the domestic market at a lower price. Consequently, Iran loses revenue, hampering economic growth. In general, economic growth largely depends on trade openness, especially for resource-rich economies.

4.4. Methodology

To explore the impact of oil rent (% of GDP) on economic growth, we use the cross-section and period fixed effect model (combined model). However, other five-panel data estimation models— pooled OLS, FE, RE, period fixed effect (PFE), period random effect (PRE)—are also considered for robustness.[47] The combined model allows us to eliminate bias arising from both unobservable variables that differ over time and across countries. For example, real GDP, trade and oil rent will differ between countries due to their differing geographies, natural endowments, political and cultural systems and other basic factors. These variables, however, do not differ over time. On the other hand, technological development or international agreements can change productivity growth globally which increases output over time. PFE model removes the effect of those country-invariant characteristics. Consequently, the combined fixed effect model removes the effect of those time-invariant and cross-section

[47] These models are described in Appendix 4.2.

invariant characteristics from the model so that we can assess the net impact of oil rent (% of GDP) on economic growth. We adopt the following combined model to examine the impact of oil rent on economic growth:

$$\Delta LGDP_{i,t} = \beta_{0i} + \beta_{0t} + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + \beta_5 LCAB_{i,t} + \beta_6 LMI_{i,t} + \beta_7 LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \varepsilon_{i,t} \quad (4.1)$$

Where $\Delta LGDP_{i,t}$ is the change in log of real GDP per capita; $\Delta LGDP_{i,t-1}$ represents the lag in the change in log of real GDP per capita; $LOIL_{i,t}$ indicates the log in oil rent (% of GDP); $LUN_{i,t}$, $LFDI_{i,t}$, $LCAB_{i,t}$ and $LMI_{i,t}$ indicate log in unemployment rate (% of total force), log in foreign direct investment (% of GDP), log in current account balance (% of GDP) and log in military expense (% of GDP) respectively; $LMOR_{i,t}$ is the log of the infant mortality rate (per 1,000 live births); and $LT_{i,t}$ represents the log of trade openness (% of GDP). A detailed description of the variables included in equation (4.1) is presented in Table A 4.1 in Appendix 4.1.

The subscripts *i* and *t* denote country and period respectively. β_{0i} and β_{0t} are the unobserved time-invariant and country-invariant individual effect respectively and the idiosyncratic disturbance term is denoted by $\varepsilon_{i,t}$. By using lag dependent variable, we capture autocorrelation in the model. In this study, we also include an interaction term in equation (4.1), denoted by $LT_{i,t} * LOIL_{i,t}$, to examine the hypothesis that trade openness significantly reduces the resource curse.

Change in GDP per capita ($\Delta LGDP_{i,t}$): Change in log of real GDP per capita is our dependent variable and is denoted by $\Delta LGDP_{i,t}$ in the model. As we want to measure the impact of oil rent (% of GDP) on the economic growth, we use change in log of real GDP per capita because it represents the level of development of a country.

Oil rent ($LOIL_{i,t}$): According to the conventional view, resource abundance stimulates economic growth. However, Sachs and Warner (1995) argue that resource abundance impedes economic growth which is known as resource curse. By following Bjorvatn, Farzanegan and Schneider (2012), Arezki and Brückner (2011), Bhattacharyya and Hodler (2010) and Collier and Hoeffler (2005), we use oil rents (% of GDP) as a measure of natural resource abundance. Rents are basically net profits from resource extraction, defined as the value of the product minus the total cost of production. Rents measure the value of natural resources for a country more precisely, providing a less ambiguous measure of resource abundance compared with those used previously such as primary commodity exports, oil exports and reserves. In this study, we expect the sign of oil rent (% of GDP) will be negative (-).

Unemployment rate ($LUN_{i,t}$): According to the Okun's law, a one per cent increase in unemployment rate causes two per cent decreases in GDP. A country faces higher costs in the form of unemployment benefits which negatively affects economic growth. An increased unemployment rate also increases the chance of social unrest. We expect the sign of this variable will be negative (-).

Foreign direct investment ($LFDI_{i,t}$): FDI plays a significant role in improving economic growth. It also indicates the strength of a country's financial market. According to Borensztein, De Gregorio and Lee (1998), FDI is an important vehicle for the transfer of technologies, knowledge and human capital, all associated with higher productivity. Thus, the relationship between FDI and change in real GDP per capita would be positive (+).

Current account balance ($LCAB_{i,t}$): It is expected that current account balance has a positive impact on economic growth. If a country's balance increases, indicating that its exports exceed its imports, that encourages investment and FDI. Sahin and Mucuk (2014) found that

current account deficit negatively affects economic growth in developing countries. Therefore, it is expected that the sign of this variable will be positive (+).

Military expense ($\boldsymbol{LM_{i,t}}$)**:** According to Cappelen, Gleditsch and Bjerkholt (1984), military expenditure reduces economic growth. As this expenditure increases, so does government total expenditure, leading to higher tax rates in the private sector that ultimately reduce private investment and the country's output. Our expected sigh of this variable is negative (-).

Mortality rate ($\boldsymbol{LMOR_{i,t}}$)**:** It is expected that decrease in mortality rate promotes economic growth. According to the Kalemli-Ozcan (2002) decrease in mortality rate reduces the precautionary demand for children and increases potential investment in each child that increases the human capital and productivity for an economy. Our expected sigh of this variable is negative (-).

Trade openness ($\boldsymbol{LT_{i,t}}$)**:** Trade openness (% of GDP) is calculated as the total of exports and imports expressed as a percentage share of GDP. According to endogenous growth theories, a country with more trade openness will grow faster than a country with a lower degree of openness, because the former has more opportunity to adopt new technologies. Also, trade openness increases the flow of international capital in the form of FDI. There is likely to be less interest in investing in an economy that imposes tariffs and non-tariff barriers on investment and that creates barriers to the repatriation of capital and profits. Consequently, trade openness boosts international trade and capital flows which stimulate economic growth. It is expected that the sign of trade openness (% of GDP) will be positive (+).

Interaction term: In this study, we are interested in the interaction between trade openness (% of GDP) and oil rent (% of GDP) to examine the hypothesis that the resource curse will decrease as the degree of trade openness increases. This is because trade openness

increases opportunities to obtain a higher price for resources in the international market and use advanced technologies to improve productivity and economic growth. We expect a positive (+) sign for this coefficient.

In equation (4.1), we use estimates for the full sample period (1980–2017) and two subsample periods (1980–1994 and 1995–2017) to allow us to examine the hypothesis that the WTO impacts the resource curse. We also estimate equation (4.1) for the alternative measures of trade openness [exports (% of GDP) and imports (% of GDP)], and alternative measure of resource abundance: natural resource rents (% of GDP).

4.5. Data and description of the variables

In this section, we discuss the definition of the variables and sources of the data. We also discuss the characteristics of the data such as unit root, descriptive statistics and correlation matrix of the variables.

4.5.1. The data

To estimate the models, this study employs an unbalanced annual panel data dataset for 95 countries covering the period 1980–2017, where the countries and period included are determined by data availability.[48] The data for real GDP per capita, oil rent, foreign direct investment, current account balance, military expense, infant mortality rate and trade openness are collected from the WDI of the WB. Unemployment rate data are collected from the WEO of the IMF.

4.5.2. Unit root test, descriptive statistics and correlation matrix

We estimate the unit root to test the stationary for all variables by using the Augmented Ducky–Fuller (ADF) and the Phillips–Perron (PP) test. With the exception of real GDP per capita, all

[48] List of 95 countries are documented in Table A 4.2 in Appendix 4.1.

variables included in the model are stationary at $p = 0.05$. The p-value of log real GDP per capita is >0.05, indicating that this variable is not stationary. To make the series stationary, we take the first difference of this series. The results of the unit root, descriptive statistics and correlation matrix are presented in Tables A 4.3, A 4.4 and A 4.5 respectively in Appendix 4.1.

4.6. Results and discussion

In this section, we describe all empirical results estimated by six estimation methods—combined model, pooled OLS, FE, RE, PFE and PRE. In Section 4.6.1, we describe the estimated coefficients for the full sample period (1980–2017) and two subsample periods (1980–1994 and 1995–2017) estimated with the combined fixed effect model.

4.6.1. Main results

Table 4.1 reports the results. In this section, we only discuss the coefficient of the variables of interest—log in oil rent, log in trade openness and the interaction term between log in oil rent and log in trade openness. Other coefficients are consistent with the literature. The coefficient of log in oil rent is negative, indicating that log in change of real GDP per capita decreases with the increase of log in oil rent and the estimated elasticity is –0.04 (see column 1 in Table 4.1). All other things being equal, a one per cent increase in oil rent is associated with a decrease in change in real GDP per capita of over 0.04 per cent. This negative association between growth in real GDP per capita and oil rent is evidence of the resource curse.

The positive coefficient of log in trade openness indicates that trade openness positively affects growth in real GDP per capita. The coefficient of the interaction term between log in trade openness and log in oil rent is also positive, indicating that opening to trade reduces the negative impact of log in oil rent on log in change of real GDP per capita. These results are significant ($p = 0.01$) and consistent with different time and country fixed effect and random

effect models. The growth impact of a marginal increase in oil rent implied from equation (4.1) is:

$$\frac{d(\Delta LGDP_{i,t})}{d(LOIL_{i,t})} = -0.04 + 0.01\ (trade\ openness)$$

We see that the resource curse is weaker where there is a higher level of trade openness. The coefficient of oil rent is –0.04, but when we add the value of interaction term the value of the coefficient becomes smaller in absolute term (–0.04 + 0.01 = |–0.03| < |–0.04|). Statistically, we can observe that resource curse decreases by 25% with the opening to trade.

Table 4.1: Change in real GDP per capita and oil rent (% of GDP) in sample period (1980–2017).

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.40***	0.46***	0.36***	0.46***	0.51***	0.51***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LOIL_{i,t}$	–0.04***	–0.02***	–0.04***	–0.02***	–0.01***	–0.01***
	(0.01)	(0.007)	(0.01)	(0.006)	(0.006)	(0.006)
	[0.01]	[0.01]	[0.01]	[0.01]	[0.009]	[0.009]
$LUN_{i,t}$	–0.0007	0.0008	–0.0008	0.0008	0.0001	0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.0009)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	–0.002	0.002	0.005	0.002	–0.003	–0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	–0.08**	–0.04*	–0.05*	–0.04*	–0.06**	–0.05**
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.03]	[0.04]	[0.03]	[0.03]	[0.03]
$LMI_{i,t}$	–0.01***	–0.002*	–0.01***	–0.002*	–0.001	–0.001
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01***	0.002***	0.01***	0.002***	0.001**	0.001**
	(0.004)	(0.0008)	(0.002)	(0.0008)	(0.0008)	(0.0008)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.0009]	[0.009]
$LT_{i,t}$	0.009**	0.003**	0.01***	0.003***	0.002**	0.002**
	(0.003)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LT_{i,t}$*$LOIL_{i,t}$	0.01***	0.005***	0.01***	0.005***	0.004***	0.004***
	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.003]	[0.002]	[0.004]	[0.002]	[0.002]	[0.002]
R^2	0.48	0.26	0.33	0.26	0.42	0.30
Adjusted R^2	0.44	0.26	0.30	0.26	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2,499	2,499	2,499	2,499	2,499	2,499

Note: Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in square brackets.

To investigate the impact of the WTO, we split our full sample period (1980–2017) into two subsample periods (1980–1994 and 1995–2017). We hypothesise that the introduction of the WTO on 1 January 1995 may have significantly increased international trade and, thereby, reduced the resource curse.[49] According to Goldstein, Rivers and Tomz (2007) and Tomz, Goldstein and Rivers (2007), participation in the WTO substantially increased trade for the whole world. Moreover, Nicita, Olarreaga and Silva (2013) demonstrate that the average country would face a 32 per cent increase in tariffs on their exports in the absence of the WTO.

In Table 4.2, we present the empirical findings on the nexus between real GDP per capita and oil rent for the two subsample periods (1980–1994 in column 1 and 1995–2017 in column 2) and compare these with the full sample period (column 3). The coefficient of log in oil rent in the period 1980–1994 is negative, and the estimated elasticity is –0.05 (column 1 in Table 4.2). All other things being equal, a one per cent increase in oil rent is associated with a significant decrease in the change of real GDP per capita of over 0.05 per cent on average. The size of the coefficient is about 40% and 20% higher than subsample period 1995–2017 (column 2) and the full sample period 1980–2017 (column 3) respectively.

From column 2 in Table 4.2, we observe that the coefficient of interaction term (between log in oil rent and log in trade openness) is positive and statistically significant during the period 1995–2017. This result indicates that trade openness has a significant impact on reducing the resource curse during that period. However, we do not find any statistically significant impact of trade openness during the period 1980–1994 (refer to column 1), although the coefficient is positive and similar with the other periods. Therefore, we can say that the result in the period 1995-2017 led to the results for the full sample period (column 3).

[49] We split sample periods based on the introduction of the WTO, not the GATT, because most economies started following the WTO's rules and regulations in 1995 (124 countries in 1995 and 164 in 2017), prior to the GATT in 1947.

Table 4.2: Change in real GDP per capita and oil rent (% of GDP) in different sample periods.

	Dependent variable: $\Delta LGDP_{i,t}$		
	1980–1994	1995–2017	1980–2017
	(1)	(2)	(3)
$\Delta LGDP_{i,t-1}$	0.32***	0.36***	0.40***
	(0.04)	(0.02)	(0.02)
	[0.05]	[0.03]	[0.03]
$LOIL_{i,t}$	–0.05*	–0.03*	–0.04***
	(0.03)	(0.01)	(0.01)
	[0.03]	[0.02]	[0.01]
$LUN_{i,t}$	–0.004	–0.002	–0.0007
	(0.004)	(0.002)	(0.001)
	[0.005]	[0.003]	[0.003]
$LFDI_{i,t}$	0.25	–0.001	–0.002
	(0.24)	(0.005)	(0.005)
	[0.23]	[0.004]	[0.004]
$LCAB_{i,t}$	–0.28**	–0.07**	–0.08**
	(0.11)	(0.03)	(0.03)
	[0.22]	[0.04]	[0.04]
$LMI_{i,t}$	–0.04***	–0.01***	–0.01***
	(0.01)	(0.004)	(0.003)
	[0.02]	[0.005]	[0.004]
$LMOR_{i,t}$	–0.0009	0.01***	0.01***
	(0.02)	(0.005)	(0.004)
	[0.02]	[0.005]	[0.004]
$LT_{i,t}$	0.02*	0.01***	0.009**
	(0.01)	(0.004)	(0.003)
	[0.01]	[0.006]	[0.004]
$LT_{i,t}$*$LOIL_{i,t}$	0.01	0.01***	0.01***
	(0.008)	(0.004)	(0.002)
	[0.008]	[0.005]	[0.003]
R^2	0.49	0.50	0.48
Adjusted R^2	0.41	0.47	0.44
Periods	15	23	38
Countries	57	95	95
Observations	564	1,935	2,499

Note: Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in square brackets.

From the above discussion, it is concluded that there is a negative relationship between log in oil rent (% of GDP) and log in change of real GDP per capita; that is, the resource curse. Although in classical theories it is assumed that an abundance of natural resources is a blessing for economic growth, we concur with Sachs and Warner (1995) who empirically show that

resources are a curse for the economy. However, we provide evidence that trade openness can reduce the resource curse.

4.6.2. Robustness results

To check the robustness of the results, we use two alternative measures of trade openness—exports (% of GDP) and imports (% of GDP).[50] Our empirical findings show that the resource curse reduces with the increase of both exports and imports. With the increase of exports, economies can gain access to international prices and earn more revenue from royalties, thereby increasing real GDP per capita. On the other hand, countries can import advance technologies to more efficiently extract oil resources and/or produce final products to earn more revenue that increases real GDP per capita. For further robustness, we use natural resource rent (% of GDP) instead of oil rent (% of GDP) as a measure of resource abundance and find similar results.[51] All robustness findings are presented in Tables A 4.6–A 4.10 in Appendix 4.3.

4.6.3. Discussion of the results

Overall, the panel data regression models suggest that having an abundance of oil resources plays a significant role in slowing economic growth—that is, it serves as a resource curse. Many reasons have been put forward in the literature for this surprising result, including rent-seeking behaviour, poor institutional quality, commodity price volatility and lack of diversification. In this study, we investigated the impact of trade openness in reducing the resource curse. Our empirical findings show that trade openness significantly decreases the resource curse in our full sample period (1980–2017). More open trade policies provide access to advanced technologies that increase efficiency by reallocating the factors of production.

[50] Exports (% of GDP) and Imports (% of GDP) represent the value of all goods and services provided and received to and from the rest of the world respectively.
[51] Natural resource rent (% of GDP) is the sum of oil rents, natural gas rents, coal rents, mineral rents and forest rents. Data for Exports (% of GDP), Imports (% of GDP) and natural resource rent (% of GDP) are collected from the WDI of the WB.

These trade policies also facilitate access to large markets where increasing competition drives innovations and strengthens managerial skills which in turn generates substantial economic growth. Accordingly, Arezki and Van der Ploeg (2011) report that the resource curse has turned into a blessing in countries with a high degree of trade openness such as Australia, Bolivia, Barbados, Canada, Chile, Malaysia and the United States.

To understand the role of the WTO in increasing merchandise trade, we split our sample period into two subsample periods, 1980–1994 (pre-WTO) and 1995–2017 (post-WTO). Our empirical findings suggest that trade openness had a significant impact on reducing the resource curse in the sample period 1995–2017. However, there was no significant effect in the sample period 1980–1994, possibly due to the fact that total merchandise trade increased after the commencement of the WTO in 1995 which helped to weaken the strength of the dynamics driving the resource curse.

Overall, based on our empirical findings, we can argue that outward-looking trade policy is helpful for economic growth and reduces the risk of experiencing the resource curse. Therefore, policymakers should concentrate on how they can make the economy more open by reducing existing tariffs and non-tariff barriers. Increased international trade (both export and import) helps economies to be more efficient by enabling the adoption of new technologies and sharing of advanced knowledge which generates long-run economic growth.

4.6.4. Marginal effect

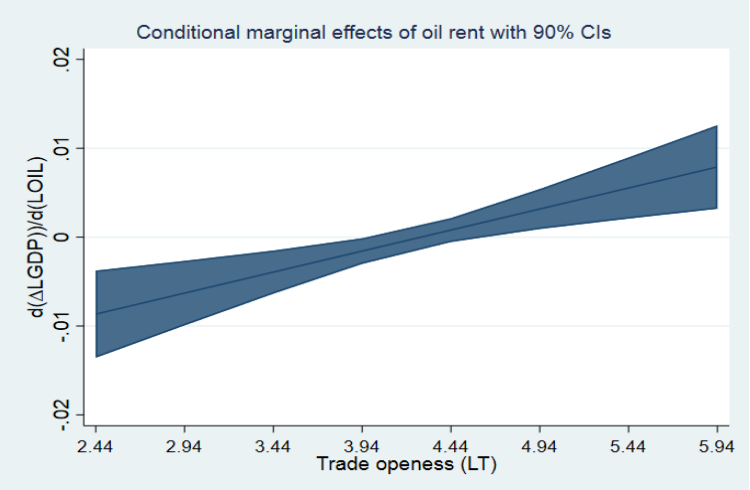
Marginal effect tells us how the dependent variable changes when a specific explanatory variable change in the regression analysis. In case of continuous variables, marginal effect measures the instantaneous rate of change. Marginal effect estimation provides a good estimate to the amount of change in the dependent variable that will be produced by a change in

independent variables. In this study, we compute the marginal effect of oil rent on the change in GDP per capita. Based on the estimates in Table 4.1, this produced:

$$\frac{d(\Delta LGDP_{i,t})}{d(LOIL_{i,t})} = -0.04 + 0.01\,(trade\ openness) \qquad (4.2)$$

From the above equation, we can see that the marginal effect of oil rent on the change in real GDP per capita is an increasing function of trade openness. Figure 4.4a−c plot the marginal effect, $\frac{d(\Delta LGDP)}{d(LOIL)}$, on the Y-axis and trade openness on the X-axis. From 4.4a plot, we can observe that the marginal effect of the oil rent on economic growth is an increasing function of trade openness in the full sample period. We also observe from Figure 4.4a that this effect becomes positive and significant with higher trade openness. In Figures 4.4b and 4.4c, we present the marginal effect of trade openness on real GDP per capita growth for the sample period 1980–1994 and 1995–2017 respectively, and we observe that in the sample period 1980–1994 there is no significant impact of trade openness on GDP. So, the results in the sample period 1995–2017 led to the results for the full sample period.[52]

Figure 4.4a: Marginal effect of oil rent on economic growth (full sample period 1980–2017)



[52] The figures of all robust analysis are presented in Appendix 4.4 (Figures A 4.1, A4.2, A4.3, A4.4, and A 4.5).

Figure 4.4b: Marginal effect of oil rent on economic growth (sample period 1980–1994)

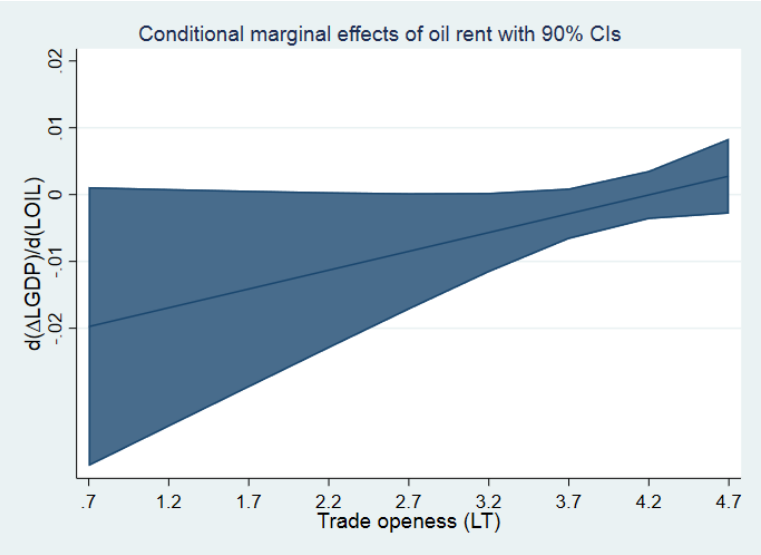
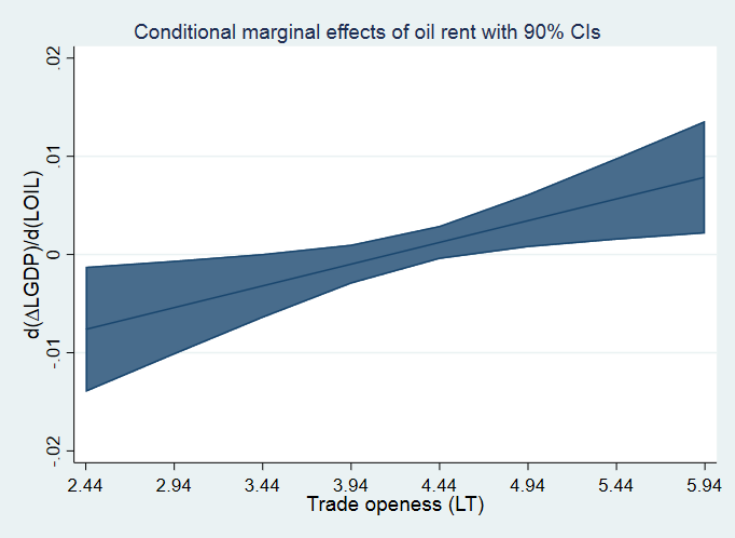


Figure 4.4c: Marginal effect of oil rent on economic growth (sample period 1995–2017)



4.7. Conclusion

This study aims to revisit the resource curse paradox and examines the role of trade openness in reducing the resource curse. Using different dynamic panel data models for 95 countries for the period 1980–2017, this study finds that economic growth decreases with the increase of oil resource abundance. A one per cent increase in oil rent causes a 0.04 per cent decrease in real GDP per capita. Although our empirical findings support the resource curse hypothesis, the study finds that trade openness is a possible channel to reduce the resource curse. On average, trade openness reduces the negative effect of oil rent on real GDP per capita by 25%. Trade openness allows countries to obtain competitive prices for their resources in the international market and access advanced technologies to more efficiently extract resources. We also find that trade openness significantly affects the resource curse after the introduction of the WTO. An important policy implication is that natural resource–rich economies that want to reduce the resource curse should consider further opening their economies.

This study can be extended by focusing on another transmission channel of the resource curse, income inequality. According to Fum and Hodler (2010) and Parcero and Papyrakis (2016), income inequality is high in resource-rich countries, especially those with point-source resources. One reason is that inefficient allocation of resources among sectors increases income inequality. Trade openness plays an important role in reallocating resources in the sectors where a country has a comparative advantage. This efficient distribution of resources helps to reduce income inequality in resource-rich countries and, thus, spurs economic growth.

Chapter 5

Overall conclusion

Commodity price volatility creates uncertainty in the economy, delays stability in government and private budgets, undermines the predictability of economic planning and ultimately contributes to lower economic growth. The literature on the impact of commodity price volatility on economic growth is extensive; however, the impact of commodity price volatility on fiscal positions is yet unexplored. To fill this gap, we explore the impact of commodity price volatility on governments' fiscal performance and external debt accumulation. In this dissertation, we explore trade openness as a channel for mitigating the oil resource curse.

In Chapter 2, we explore the impact of commodity price volatility on fiscal balance using dynamic panel data models for 108 countries from the period 1993 to 2018. Our empirical findings show that government fiscal balance decreases with commodity price volatility. After examining the impact of commodity price volatility in all countries in the sample, we classified the sample countries as commodity-exporting and commodity-importing to examine the hypothesis that this impact of commodity price volatility on fiscal balance differs with the level of resource endowment. Our empirical findings indicate that commodity price volatility negatively affects fiscal balance in commodity-exporting countries; however, this impact is statistically insignificant in commodity-importing countries. In addition, we examine the role of the real interest rate in influencing the relationship between commodity price volatility and fiscal balance. We find that lower real interest rates may be effective in reducing the negative impact of commodity price volatility on fiscal balance.

In the Chapter 3 of this dissertation, we explore the impact of commodity price volatility on external debt accumulation using dynamic panel data models for 97 countries from the period 1993 to 2016. The results show that external debt accumulation increases with

commodity price volatility. When we split the sample countries into commodity exporters and importers, our empirical findings show that commodity price volatility has a statistically significant impact on the growth in external debt in commodity-exporting countries; however, this effect is statistically insignificant in commodity-importing countries.

In addition, we examine the impact of commodity price volatility in three different exchange rate regimes: fixed, managed floating and freely floating exchange. Our empirical findings show that the adverse impact of commodity price volatility on external debt is statistically insignificant in countries with a floating exchange rate regime. However, we find that the impact is larger and statistically significant in countries with a completely fixed exchange rate regime than those with a managed floating exchange rate regime. Based on these results, it is concluded that the adoption of exchange rate regimes determined by markets (freely floating) is critical to reducing the impact of commodity price volatility on external debt.

In the fourth chapter, we revisit the 'resource curse' paradox in terms of oil resource abundance and examine the role of trade openness in reducing the 'oil curse'. Using different dynamic panel data models for 95 countries for the period from 1980 to 2017, we find that economic growth decreases with the increase of oil resource abundance. Although our empirical findings support the so-called 'resource curse' hypothesis, this study finds that trade openness is a possible avenue to reduce the resource curse. Trade openness allows countries to obtain competitive prices for their resources in the international market and access advanced technologies to extract resources more efficiently. Therefore, natural resource-rich economies can reduce the resource curse by opening themselves to international trade.

In conclusion, this dissertation provides a deeper understanding of the nexus between commodity prices and the macroeconomy. In all three chapters, we provide empirical evidence of three different policy instruments: lower real interest rates (Chapter 2), floating exchange rate regimes (Chapter 3); and higher trade openness (Chapter 4). These instruments may be

effective in reducing the negative impact of commodity abundance on the macroeconomy. Therefore, this dissertation may serve as a reference for future studies and policymakers to ensure that natural resources are a blessing for the economy, not a curse.

Appendix 2.1

Table A 2.1: Description of the variables

Variables	Mnemonic	Description	Source
Dependent variable			
Fiscal balance (% of GDP)	$FB_{i,t}$	Primary net lending/borrowing is net lending (+)/borrowing (–) plus net interest payable/paid.	WEO, IMF
Control variables			
Commodity prices	$CP_{i,t}$	All commodity price index using 2016 = 100 includes both fuel and non-fuel price indices.	Commodity data portal, IMF
Commodity price volatility	$CPV_{i,t}$	Use standard deviation to estimate volatility.	Author's calculation
Gross capital formation (annual % growth)	$CAP_{i,t}$	Annual growth rate of gross capital formation based on constant 2010 U.S. Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.	WDI, WB
GDP per capita growth (annual %)	$GDP_{i,t}$	Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. GDP per capita is gross domestic product divided by midyear population..	WDI, WB
Military expenditure (% of GDP)	$MI_{i,t}$	Military expenditures data from SIPRI are derived from the NATO definition, which includes all expenses.	WDI, WB
Real interest rate (%)	$RIR_{i,t}$	Real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator.	WDI, WB
Individual commodities crude oil, still, iron ore, soybean, maize, gold, copper, silver, aluminium and gas		All commodity price index using 2016 = 100.	Commodity data portal, IMF

Note: We use percentage change to obtain the data in stationary in commodity prices series and expressed as $PCCP_{i,t}$ in equation 2.1.

Table A 2.2: List of countries (n=108)

Albania	Cote d'Ivoire	Liberia	Qatar
Algeria	Croatia	Macedonia, FYR	Romania
Angola	Czech Rep.	Madagascar	Russian Federation
Argentina	Dominican Republic	Malawi	Rwanda
Armenia	Egypt, Arab Rep.	Malaysia	Senegal
Australia	The Gambia	Mali	Serbia
Azerbaijan	Georgia	Malta	Seychelles
Bahrain	Guatemala	Mauritia	Sierra Leone
Bangladesh	Guinea	Mauritius	South Africa
Belarus	Haiti	Mexico	South Sudan
Belize	Honduras	Moldova	Sri Lanka
Benin	Hungary	Mongolia	Swaziland
Bolivia	India	Montenegro	Sweden
Bosnia and Herzegovina	Indonesia	Mozambique	Switzerland
Botswana	Iran	Namibia	Tajikistan
Brazil	Israel	Netherlands	Tanzania
Brunei Darussalam	Italy	New Zealand's	Thailand
Bulgaria	Jamaica	Nicaragua	Timor
Burkina Faso	Japan	Niger	Togo
Burundi	Jordan	Nigeria	Uganda
Cabo Verde	Kenya	Oman	Ukraine
Canada	Korea	Pakistan	UK
Chile	Kuwait	Panama	USA
China	Kyrgyz	Papua New	Uruguay
Colombia	Lao PDR	Paraguay	Venezuela
Congo, Dem. Rep	Lebanon	Peru	Vietnam
Costa Rica	Lesotho	Philippines	Zimbabwe

Table A 2.3: List of commodity-exporting and commodity-importing countries

Commodity-exporting (n=45)		Commodity-importing (n=63)	
Algeria	Paraguay	Albania	Lesotho
Argentina	Peru	Angola	Liberia
Armenia	Russian Federation	Azerbaijan	Macedonia, FYR
Australia	Rwanda	Bangladesh	Madagascar
Bahrain	Senegal	Belarus	Malaysia
Benin	Sierra Leone	Belize	Malta
Bolivia	Tajikistan	Bosnia and Herzegovina	Mauritius
Botswana	Tanzania	Brazil	Mexico
Burundi	Togo	Brunei Darussalam	Mongolia
Chile	Uganda	Bulgaria	Montenegro
Colombia	Uruguay	Burkina Faso	Netherlands
Cote d'Ivoire	Venezuela	Cabo Verde	Nigeria
Egypt, Arab Rep	Zimbabwe	Canada	Oman
The Gambia		China	Pakistan
Guatemala		Congo, Dem. Rep	Philippines
Honduras		Costa Rica	Qatar
Indonesia		Croatia	Romania
Iran		Czech Rep.	Serbia
Kenya		Dominican Republic	Seychelles
Korea		Georgia	South Africa
Kyrgyz Republic		Guinea	South Sudan
Malawi		Haiti	Sri Lanka
Mali		Hungary	Swaziland
Mauritia		India	Sweden
Moldova		Israel	Switzerland
Mozambique		Italy	Thailand
Namibia		Jamaica	Timor
New Zealand’s		Japan	Ukraine
Nicaragua		Jordan	UK
Niger		Kuwait	USA
Panama		Lao PDR	Vietnam
Papua New		Lebanon	

Table A 2.4: Unit root test

	Augmented Ducky-Fuller (ADF)		Phillips–Peron (PP)	
	Statistics	*p*-value	Statistics	*p*-value
$FB_{i,t}$	435.61	0.00	527.65	0.00
$CPV_{i,t}$	414.06	0.00	680.72	0.00
$CP_{i,t}$	105.14	1.00	99.09	1.00
$PCCP_{i,t}$	935.95	0.00	1334.24	0.00
$CAP_{i,t}$	905.87	0.00	1543.85	0.00
$GDP_{i,t}$	1050.09	0.00	1175.65	0.00
$MI_{i,t}$	445.25	0.00	697.73	0.00
$RIR_{i,t}$	687.86	0.00	1037.70	0.00

Note: $FB_{i,t}$ = Fiscal balance, $CPV_{i,t}$ = Commodity price volatility, $CP_{i,t}$ = Commodity prices, $PCCP_{i,t}$ = Percentage change in commodity prices, $CAP_{i,t}$ = Capital growth and $GDP_{i,t}$ = Gross domestic product. $RIR_{i,t}$ = Real interest rate.

Table A 2.5: Descriptive statistics

	$FB_{i,t}$	$CPV_{i,t}$	$CP_{i,t}$	$PCCP_{i,t}$	$CAP_{i,t}$	$GDP_{i,t}$	$MI_{i,t}$	$RIR_{i,t}$
Mean	–0.56	7.25	110.02	1.83	7.36	2.47	1.95	6.74
Median	–0.61	5.31	113.57	6.17	5.25	2.52	1.58	5.52
Maximum	36.01	30.37	182.70	20.84	744.86	38.70	12.06	93.91
Minimum	–35.06	0.99	48.04	–46.81	–164.50	–47.59	0.00	–69.53
Standard Deviation	4.60	6.20	44.18	18.38	31.21	4.14	1.48	10.34
Skewness	0.33	2.45	0.11	–1.22	11.96	–0.45	2.21	1.06
Kurtosis	13.03	9.66	1.68	3.95	248.23	23.05	10.68	13.85
Observations	1964	1964	1964	1964	1964	1964	1964	1964

Note: $FB_{i,t}$ = Fiscal balance, $CPV_{i,t}$ = Commodity price volatility, $CP_{i,t}$ = Commodity prices, $PCCP_{i,t}$ = Percentage change in commodity prices, $CAP_{i,t}$ = Capital growth and $GDP_{i,t}$ = Gross domestic product. $RIR_{i,t}$ =Real interest rate.

Table A 2.6: Correlation matrix

	$FB_{i,t}$	$CPV_{i,t}$	$PCCP_{i,t}$	$CAP_{i,t}$	$GDP_{i,t}$	$MI_{i,t}$	$RIR_{i,t}$
$FB_{i,t}$	1.00						
$CPV_{i,t}$	0.003	1.00					
$PCCP_{i,t}$	0.19	0.02	1.00				
$CAP_{i,t}$	0.06	0.009	0.10	1.00			
$GDP_{i,t}$	0.14	0.01	0.25	0.23	1.00		
$MI_{i,t}$	–0.08	–0.04	–0.02	–0.007	–0.11	1.00	
$RIR_{i,t}$	–0.08	–0.08	–0. 61	–0.01	–0.02	–0.06	1.00

Note: $FB_{i,t}$ = Fiscal balance, $CPV_{i,t}$= Commodity price volatility, $PCCP_{i,t}$ = Percentage change in commodity prices, $CAP_{i,t}$ = Capital growth and $GDP_{i,t}$ = Gross domestic product. $RIR_{i,t}$ =Real interest rate.

Appendix 2.2

A 2.2.1. Pooled OLS model

In the pooled OLS model, we have pooled all observations in OLS regression, meaning that, implicitly, we assume that the coefficient is the same for each individual country. Thus, the model (2.1) follows the form:

$$FB_{i,t} = \beta_0 + \beta_1 FB_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 CAP_{i,t} + \Sigma_{i=0}^{n} \beta_5 GDP_{i,t} + \beta_6 MI_{i,t} + \beta_7 RIR_{i,t} + \beta_8 RIR_{i,t} * CPV_{i,t} + \varepsilon_{i,t} \quad (2.5)$$

A 2.2.2. RE model

The rationale of the RE model is that, unlike the FE model, the variation between entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. For example, in the RE model, it is assumed that the unobserved effects (e.g., geographical factors, natural endowments, political and cultural systems) are not correlated with commodity prices or fiscal balance. The RE model includes all FE assumptions as well as an additional requirement that (Ω_i) is independent of all explanatory variables in all time periods. Hence, the variability of the constant for each section originates from:

$$\beta_{0i} = \beta_0 + \Omega_i \quad (2.6)$$

where Ω_i is a zero-mean standard random variable. Therefore, equation (2.1) with random effects takes the following form:

$$FB_{i,t} = \beta_0 + \beta_1 FB_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 CAP_{i,t} + \beta_5 GDP_{i,t} + \Sigma_{i=0}^{n} \beta_6 MI_{i,t} + \beta_7 RIR_{i,t} + \beta_{18} RIR_{i,t} * CPV_{i,t} + \Omega_i + \varepsilon_{i,t} \quad (2.7)$$

We estimate equations 2.5 and 2.7 for all countries and commodity groups mentioned above.

A 2.2.3. Hausman test

Null hypothesis: RE model is appropriate

Alternative hypothesis: FE model is appropriate

Table A 2.2.1: Results of the Hausman test

Country groups	Chi-Sq. Statistics	*p*-value	Comments
Full Sample	243.97	0.00	Reject Null hypothesis
Commodity-exporting countries	90.85	0.00	Reject Null hypothesis
Commodity-importing countries	154.03	0.00	Reject Null hypothesis

From Table A 2.2.1, we can observe that the *p*-value of the Hausman test is less than 5%, indicating that we can reject the null hypothesis and accept the alternative hypothesis that the FE model is appropriate. This result is consistent for all three country groups.

Appendix 2.3

Figures A 2.1a, A 2.1b and A 2.1c show the marginal effect of oil price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.1a: Impact of oil price volatility on fiscal balance (Full sample)

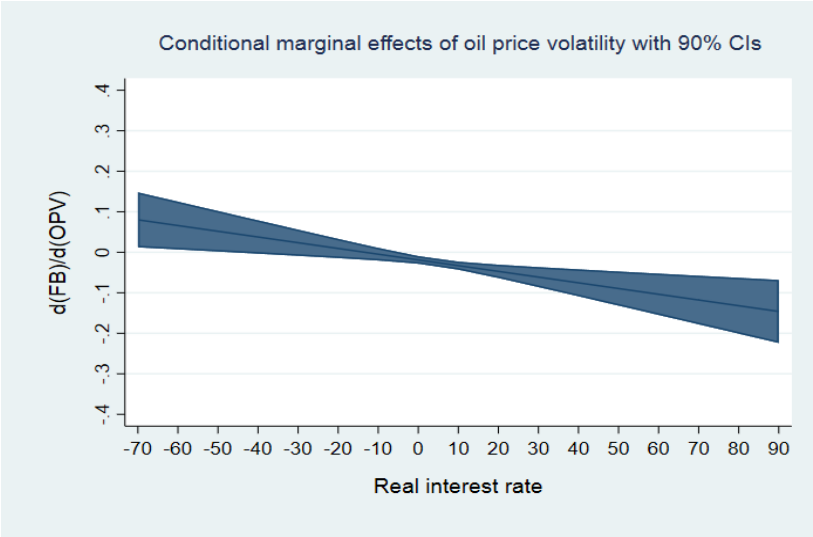


Figure A 2.1b: Impact of oil price volatility on fiscal balance (Commodity-exporting)

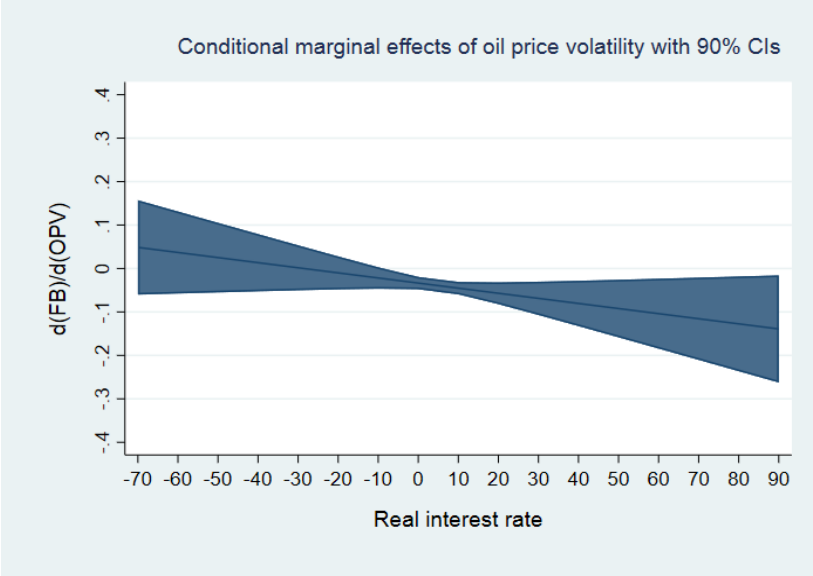
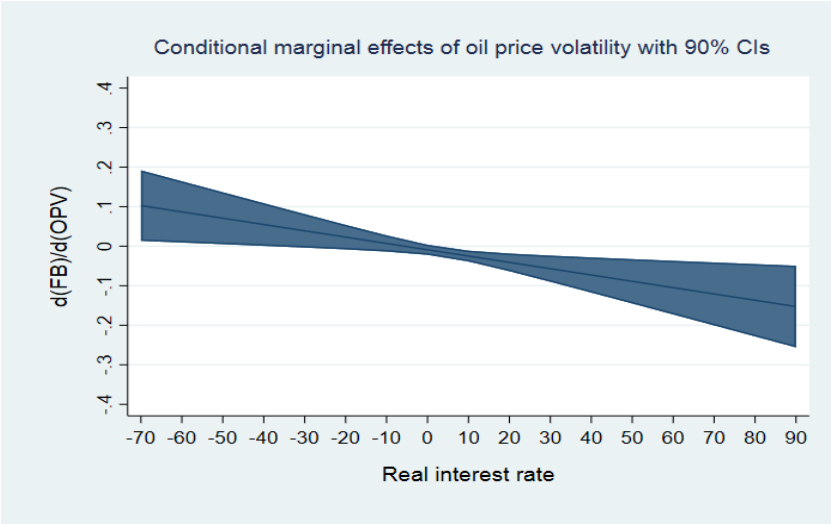


Figure A 2.1c: Impact of oil price volatility on fiscal balance (Commodity-importing)



Figures A 2.2a, A 2.2b and A 2.2c show the marginal effect of steel price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.2a.: Impact of steel price volatility on fiscal balance (Full sample)

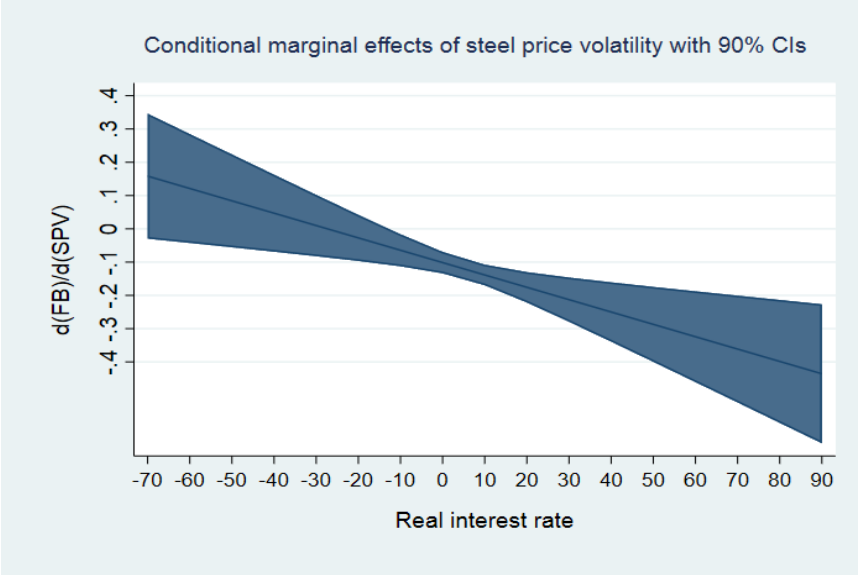


Figure A 2.2b.: Impact of steel price volatility on fiscal balance (Commodity-exporting)

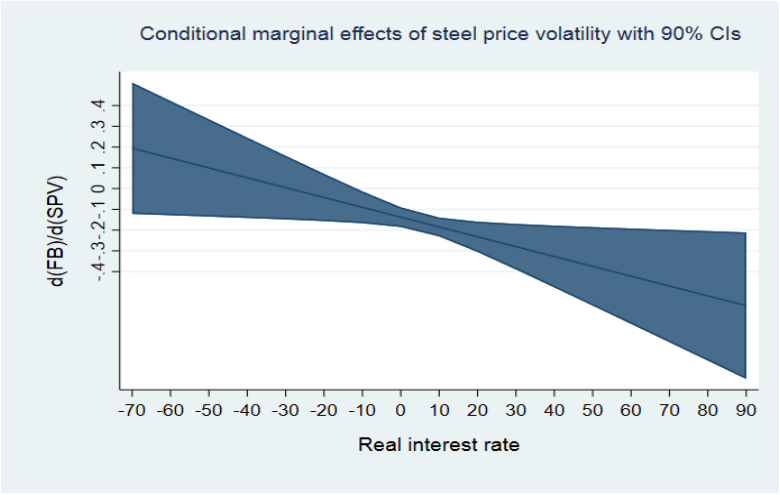
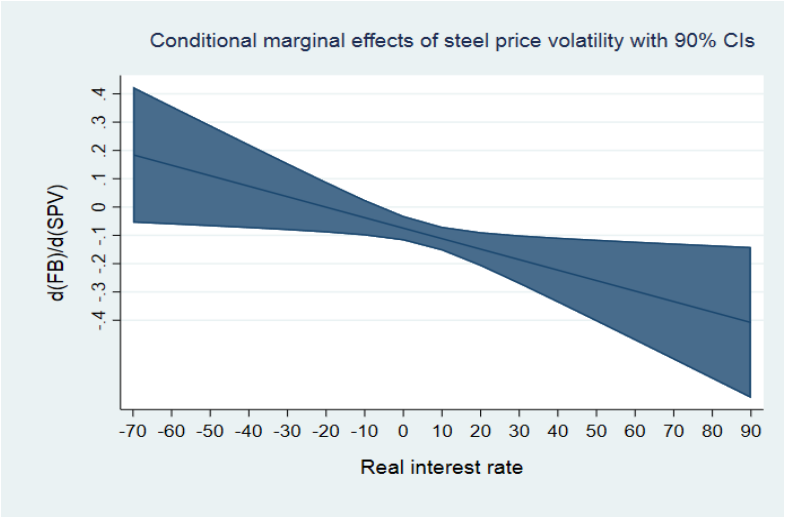


Figure A 2.2c.: Impact of steel price volatility on fiscal balance (Commodity-importing)



Figures A 2.3a, A 2.3b and A 2.3c show the marginal effect of silver price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.3a.: Impact of silver price volatility on fiscal balance (Full sample)

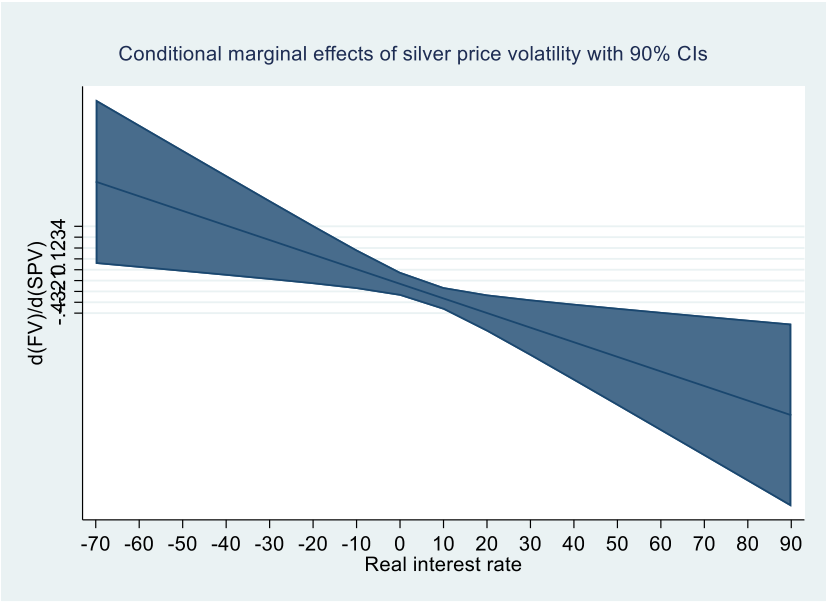


Figure A 2.3b: Impact of silver price volatility on fiscal balance (Commdoity-exporting)

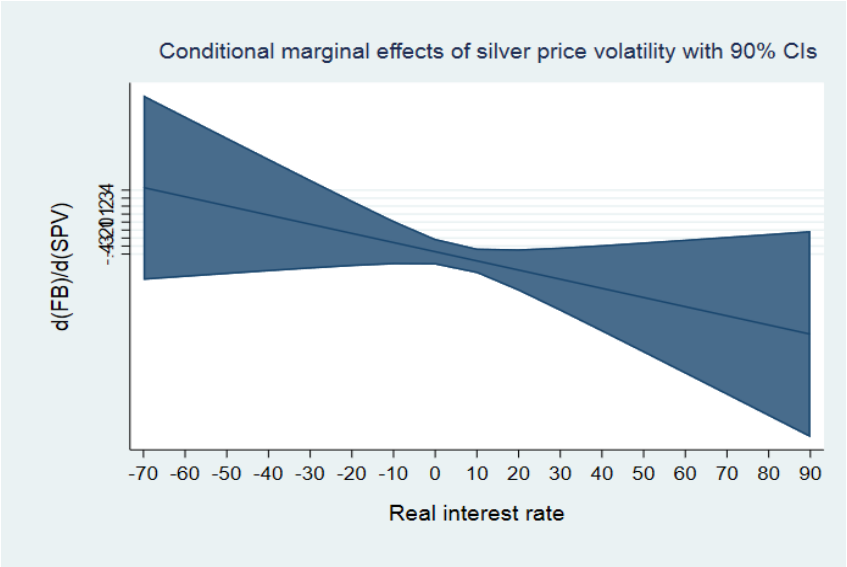
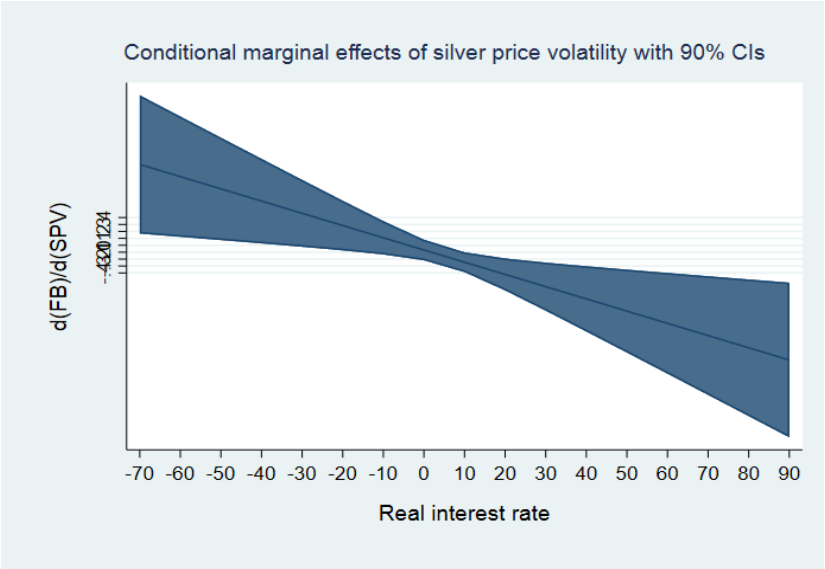


Figure A 2.3c: Impact of silver price volatility on fiscal balance (Commdoity-importing)



Figures A 2.4a, A 2.4b and A 2.4c show the marginal effect of soybean price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.4a: Impact of soybean price volatility on fiscal balance (Full sample)

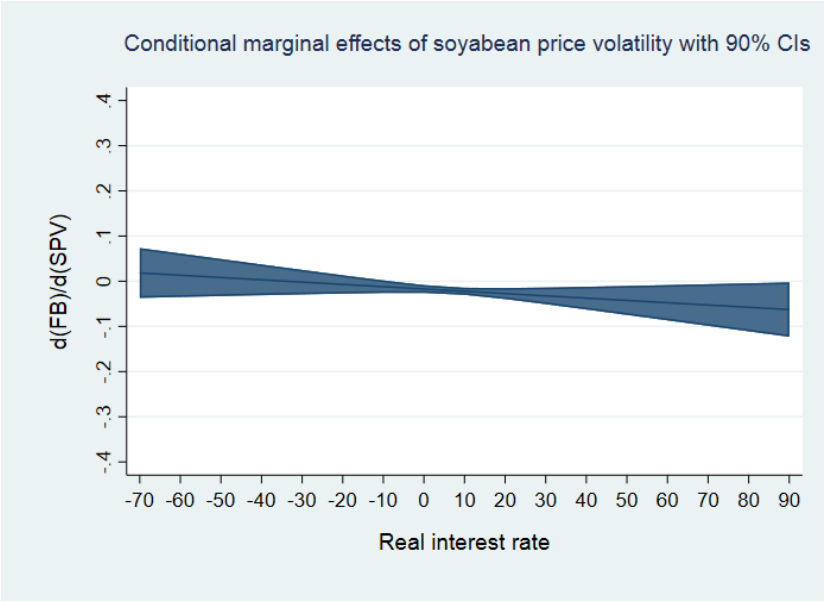


Figure A 2.4b: Impact of soybean price volatility on fiscal balance (Commodity-exporting)

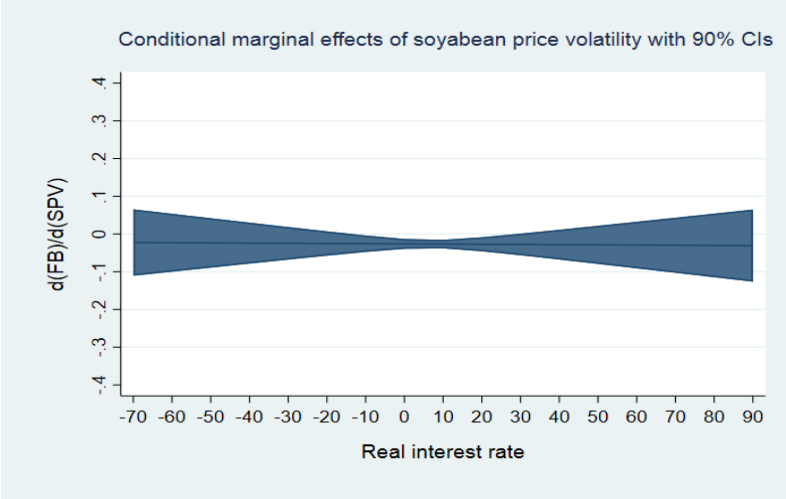
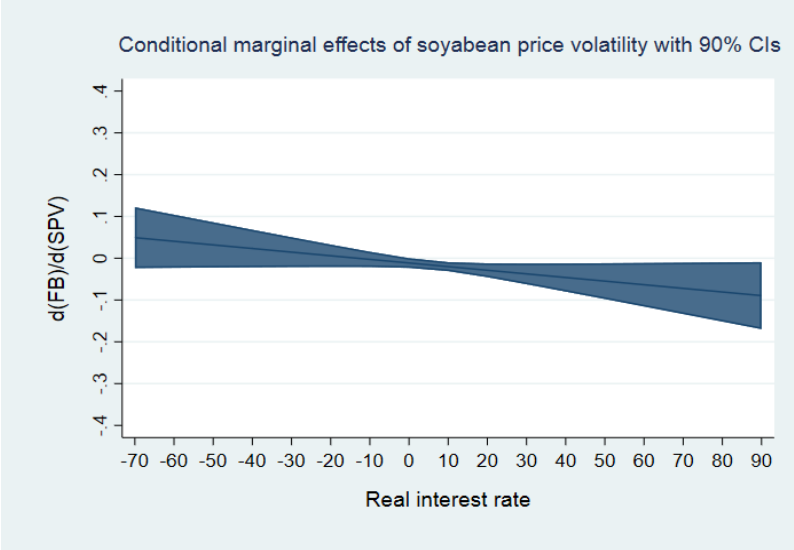


Figure A 2.4c: Impact of soybean price volatility on fiscal balance (Commodity-importing)



Figures A 2.5a, A 2.5b and A 2.5c show the marginal effect of gold price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.5a: Impact of gold price volatility on fiscal balance (Full sample)

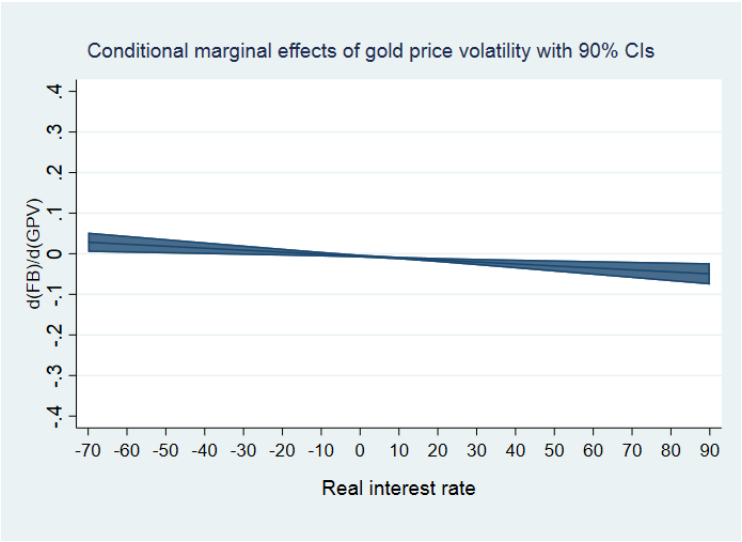


Figure A 2.5b: Impact of gold price volatility on fiscal balance (Commodity-exporting)

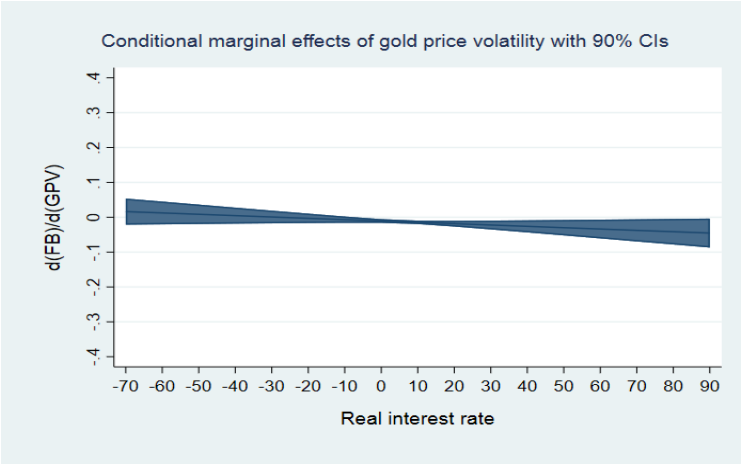
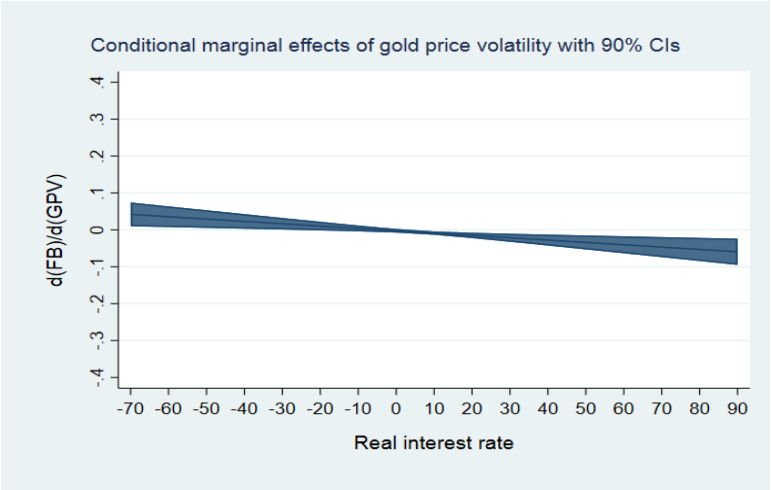


Figure A 2.5c: Impact of gold price volatility on fiscal balance (Commodity-importing)



Figures A 2.6a, A 2.6b and A 2.6c show the marginal effect of coper price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.6a: Impact of coper price volatility on fiscal balance (Full sample)

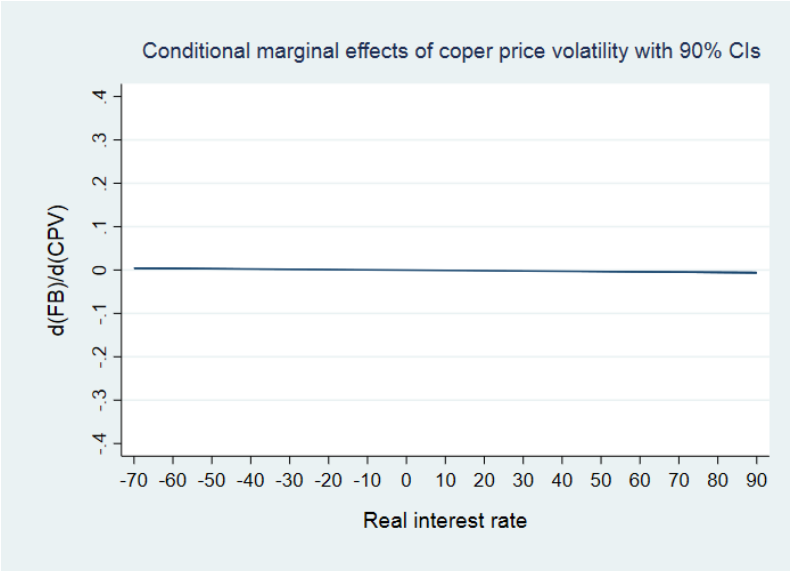


Figure A 2.6b: Impact of coper price volatility on fiscal balance (Commodity-exporting)

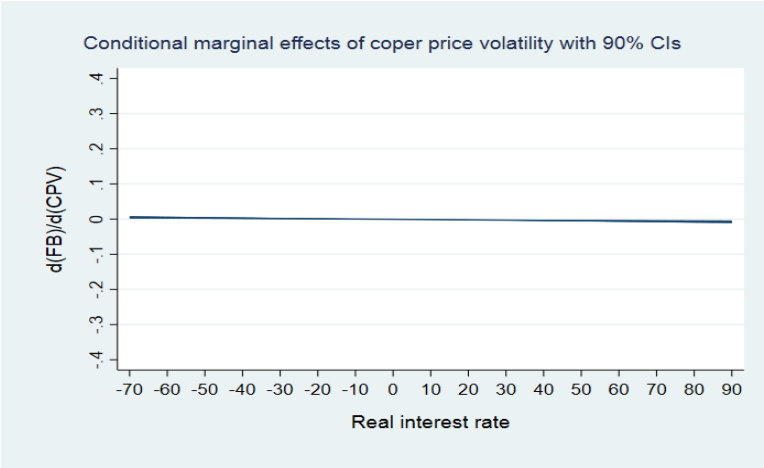
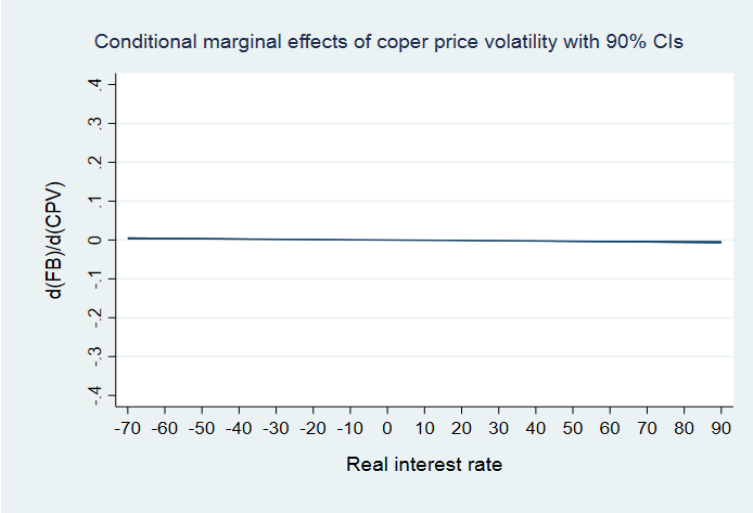


Figure A 2.6c: Impact of coper price volatility on fiscal balance (Commodity-importing)



Figures A 2.7a, A 2.7b and A 2.7c show the marginal effect of maize price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.7a: Impact of maize price volatility on fiscal balance (Full sample)

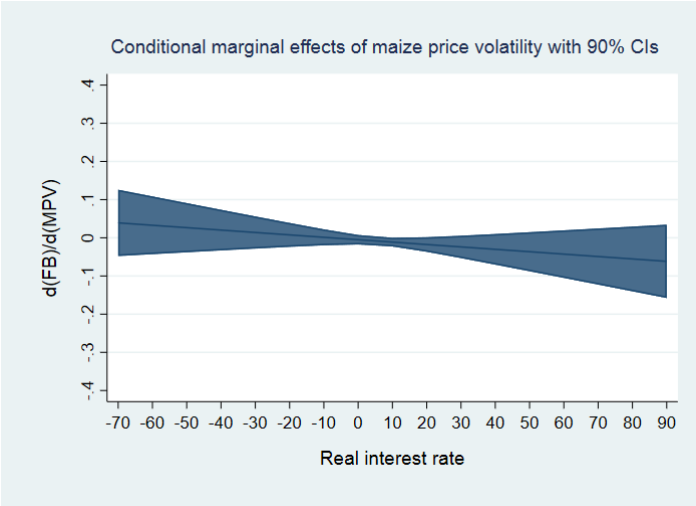


Figure A 2.7b: Impact of maize price volatility on fiscal balance (Commodity-exporting)

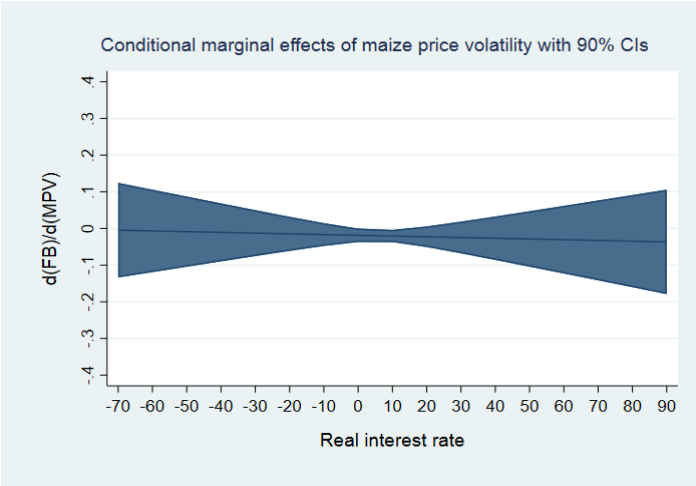
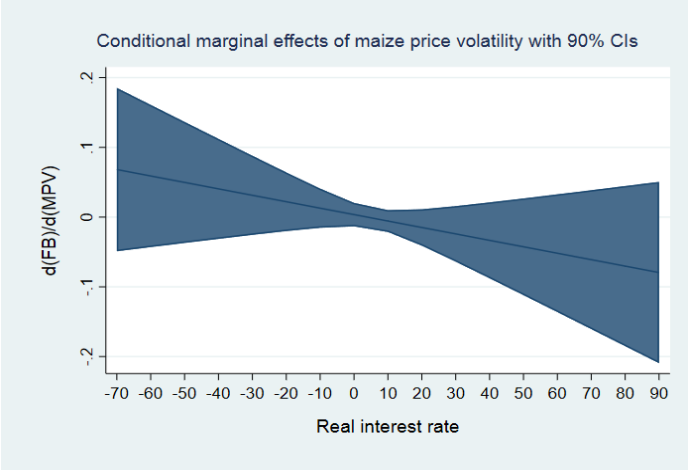


Figure A 2.7c: Impact of maize price volatility on fiscal balance (Commodity-importing)



Figures A 2.8a, A 2.8b and A 2.8c show the marginal effect of aluminium price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.8a: Impact of aluminium price volatility on fiscal balance (Full sample)

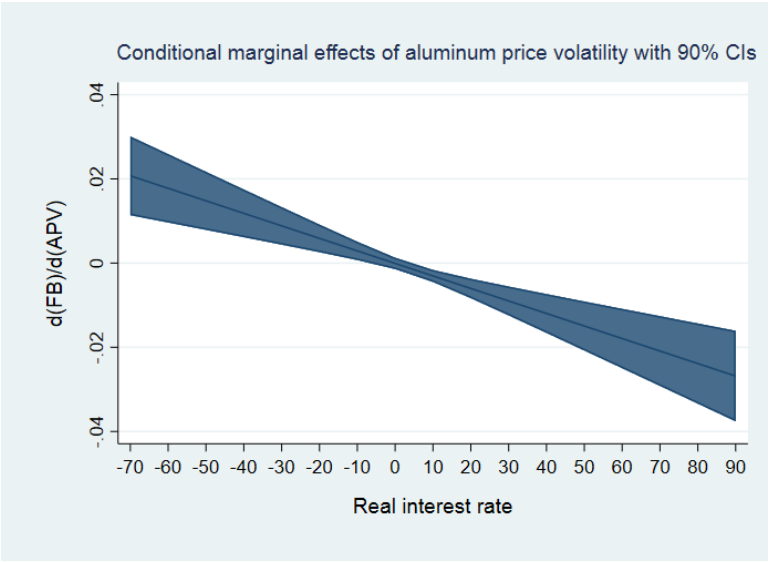


Figure A 2.8b: Impact of aluminium price volatility on fiscal balance (Commodity-exporting)

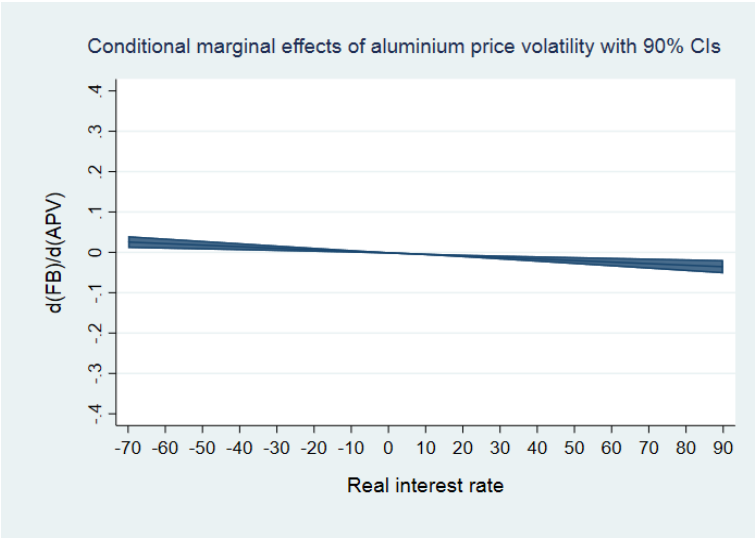
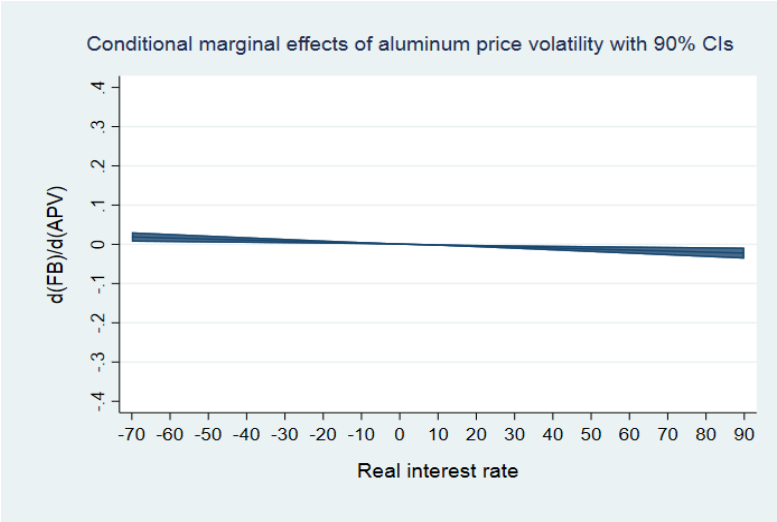


Figure A 2.8c: Impact of aluminium price volatility on fiscal balance (Commodity-importing)



Figures A 2.9a, A 2.9b and A 2.9c show the marginal effect of iron ore price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.9a: Impact of iron ore price volatility on fiscal balance (Full sample)

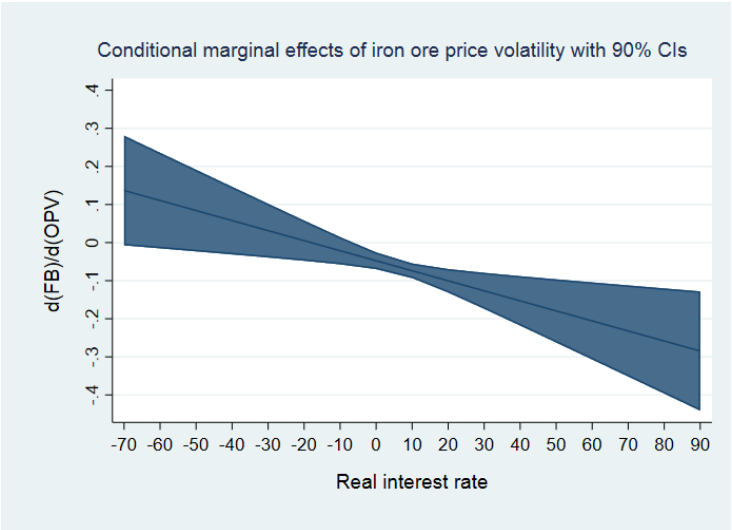


Figure A 2.9b: Impact of iron ore price volatility on fiscal balance (Commodity-exporting)

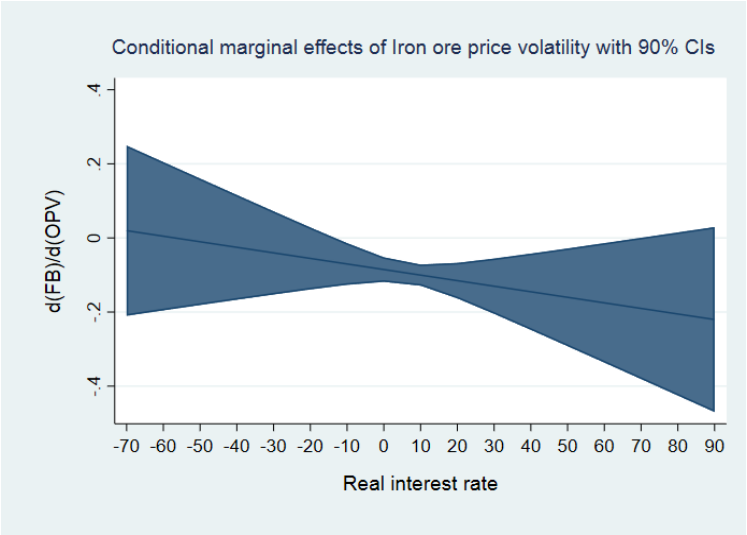
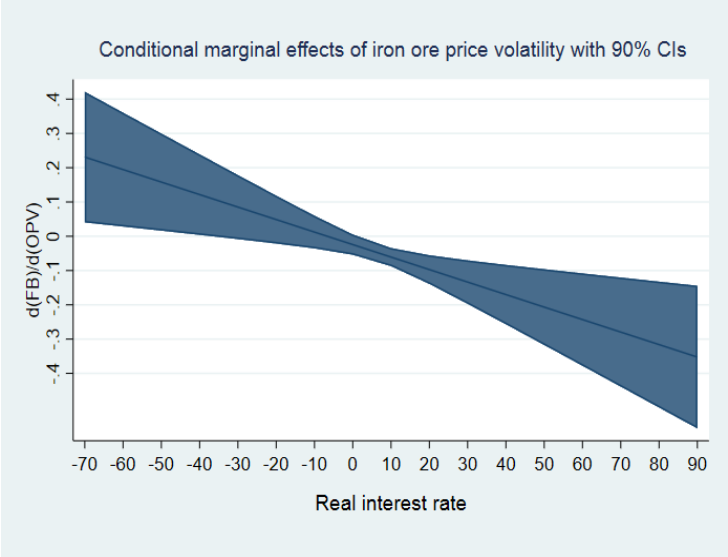


Figure A 2.9c: Impact of iron ore price volatility on fiscal balance (Commodity-importing)



Figures A 2.10a, A 2.10b and A 2.10c show the marginal effect of gas price volatility on fiscal balance for the full sample, commodity-exporting and commodity-importing countries respectively.

Figure A 2.10a: Impact of gas price volatility on fiscal balance (Full sample)

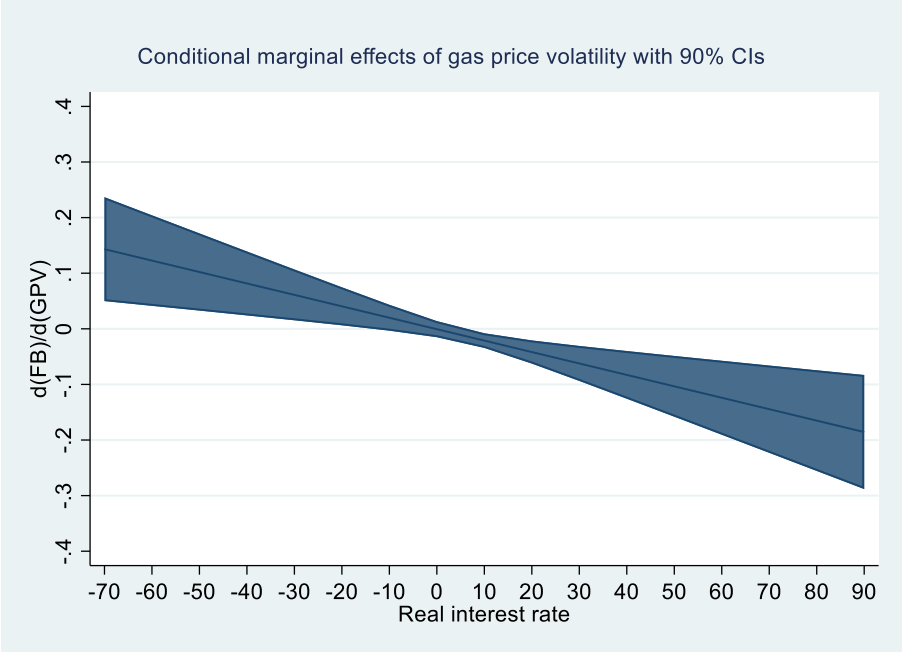


Figure A 2.10b: Impact of gas price volatility on fiscal balance (Commodity-exporting)

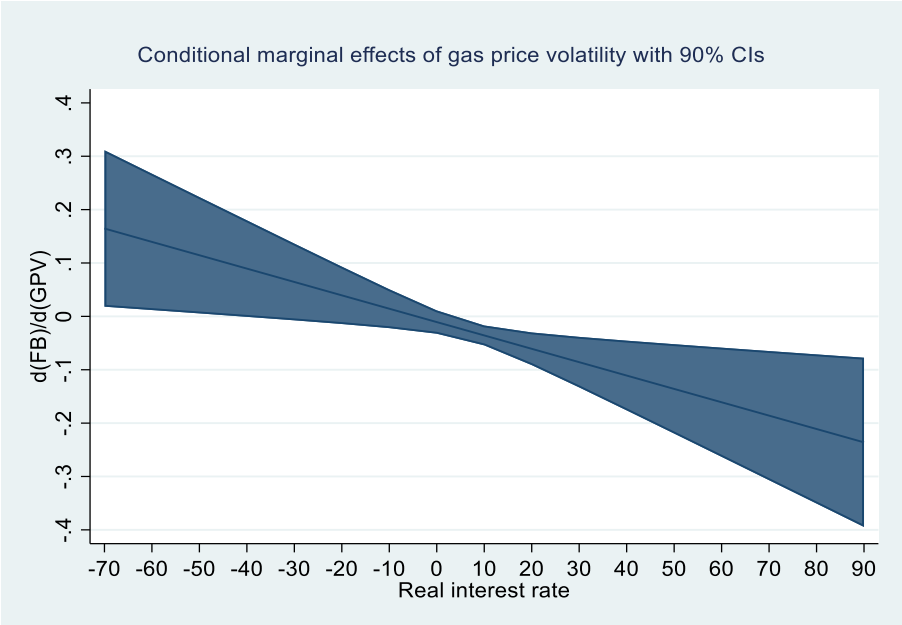
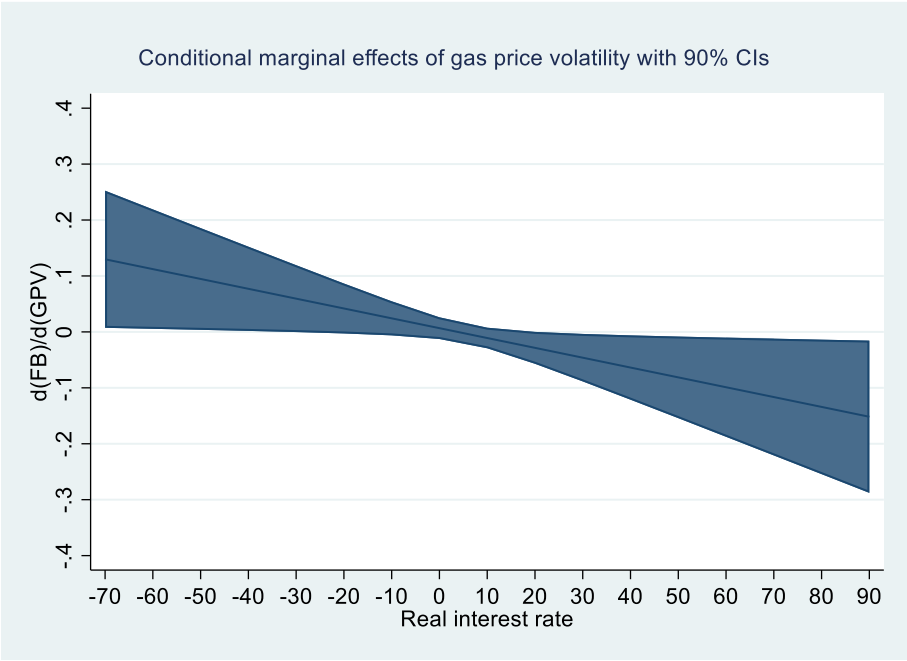


Figure A 2.10c: Impact of gas price volatility on fiscal balance (Commodity-importing)



Appendix 3.1

Table A 3.1: Description of the variables

Variables	Mnemonic	Description	Source
Dependent variable			
External debt (% of GNI)	$ED_{i,t}$	Total external debt stocks to gross national income is a debt owed to non-residents repayable in currency, goods, or services.	WDI, WB
Control variables			
Commodity prices	$CP_{i,t}$	All commodity price index using 2005=100, includes both fuel and non-fuel price indices.	Commodity data portal, IMF
Commodity price volatility	$CPV_{i,t}$	Use standard deviation to estimate volatility.	Author's calculation
Real interest rate (%)	$RIR_{i,t}$	The real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator.	WDI, WB
Foreign direct investment, net inflows (% of GDP)	$FDI_{i,t}$	Foreign direct investment is the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy.	WDI, WB
Current account balance (% of GDP)	$CAB_{i,t}$	The current account balance is the sum of net exports of goods and services, net primary income, and net secondary income.	WDI, WB
GDP per capita growth (annual %)	$GDP_{i,t}$	Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.	WDI, WB
Exchange rate regimes			
Natural regime classification		i. **Fixed exchange rate regimes:** No separate legal tender, and currency board arrangements. Dummy variable which takes the value of 1 if the country uses fine classification 1-2 and 0 otherwise. ii. **Managed floating regimes:** Limited flexibility regimes Dummy variable which takes the value of 1 if the country uses fine classification 3-12 and 0 otherwise. iii. **Floating exchange rate regimes:** Freely floating, and freely falling. Dummy variable which takes the value of 1 if the country uses fine classification 13-15 and 0 otherwise.	Reinhart, Ilzetzki & Rogoff (2009).

Note: We use percentage change to get the data in stationary in external debt and commodity price series and expressed as $PCED_{i,t}$ and $PCCP_{i,t}$ respectively in equation (3.1).

Table A 3.2: List of countries (n =97)

Afghanistan	Congo, Rep.	Liberia	Rwanda
Albania	Costa Rica	Macedonia, North	Samoa
Angola	Cote d'Ivoire	Malawi	Sao Tome
Argentina	Dominica	Malaysia	Senegal
Armenia	Dominican Republic	Maldives	Sierra Leone
Azerbaijan	Egypt, Arab Rep.	Mali	Solomon Islands
Bangladesh	El Salvador	Mauritius	South Africa
Belarus	Fiji	Mexico	Sri Lanka
Belize	Gabon	Moldova	St. Lucia
Benin	The Gambia	Mongolia	St. Vincent
Bhutan	Georgia	Montenegro	Syrian Arab Rep.
Bolivia	Grenada	Morocco	Tajikistan
Bosnia and Herzegovina	Guatemala	Mozambique	Tanzania
Botswana	Guinea-Bissau	Myanmar	Thailand
Brazil	Guyana	Nepal	Togo
Burkina Faso	Haiti	Nicaragua	Tonga
Burundi	Honduras	Nigeria	Uganda
Cabo Verde	India	Pakistan	Ukraine
Cameroon	Indonesia	Panama	Vanuatu
Central African Rep.	Jamaica	Papua New Guinea	Venezuela
Chad	Jordan	Paraguay	Vietnam
China	Kenya	Peru	Zambia
Colombia	Kyrgyz Republic	Philippines	
Comoros	Lebanon	Romania	
Congo, Dem.	Lesotho	Russian Federation	

Table A 3.3: List of commodity-exporting and commodity-importing countries

Commodity-exporting countries (n = 41)		Commodity-importing countries (n = 56)	
Argentina	Paraguay	Afghanistan	Lesotho
Armenia	Peru	Albania	Liberia
Benin	Russia	Angola	Macedonia, North
Bolivia	Rwanda	Azerbaijan	Malaysia
Botswana	Senegal	Bangladesh	Maldives
Burundi	Sierra	Belarus	Mauritius
Cameroon	Syria	Belize	Mexico
Central African Rep.	Tajikistan	Bhutan	Mongolia
Colombia	Tanzania	Bosnia	Montenegro
Congo, Rep.	Togo	Brazil	Morocco
Cote d'Ivoire	Uganda	Burkina Faso	Myanmar
Egypt	Venezuela	Cabo Verde	Nepal
Fiji	Zambia	Chad	Nigeria
Gabon		China	Pakistan
The Gambia		Comoros	Philippines
Guatemala		Congo, Dem.	Romania
Guyana		Costa Rica	Samoa
Honduras		Dominica	Sao Tome
Indonesia		Dominican Rep.	Solomon Islands
Kenya		El Salvador	South Africa
Kyrgyz Republic		Georgia	Sri Lanka
Malawi		Grenada	St. Lucia
Mali		Guinea-Bissau	St. Vincent
Moldova		Haiti	Thailand
Mozambique		India	Tonga
Nicaragua		Jamaica	Ukraine
Panama		Jordan	Vanuatu
Papua New Guinea		Lebanon	Vietnam

Table A 3.4: Unit root test

	Augmented Ducky–Fuller (ADF)		Phillips–Peron (PP)	
	Statistics	p-value	Statistics	P-value
$ED_{i,t}$	196.06	0.44	214.00	0.15
$PCED_{i,t}$	850.77	0.00	2898.31	0.00
$CPV_{i,t}$	336.65	0.00	493.34	0.00
$CP_{i,t}$	101.60	1.00	92.71	1.00
$PCCP_{i,t}$	460.99	0.00	980.37	0.00
$RIR_{i,t}$	576.98	0.00	1063.64	0.00
$FDI_{i,t}$	387.56	0.00	524.20	0.00
$CAB_{i,t}$	383.38	0.00	391.70	0.00
$GDP_{i,t}$	962.23	0.00	1076.96	0.00

Note: $ED_{i,t}$ = Externa debt, $PCED_{i,t}$ = Percentage change in external debt, $CPV_{i,t}$= Commodity price volatility, $CP_{i,t}$= Commodity prices, $\Delta CP_{i,t}$ = Percentage change in commodity prices, $RIR_{i,t}$ =Real interest rate, $FDI_{i,t}$ = Foreign direct investment, and $CAB_{i,t}$ = Current account balance, and $GDP_{i,t}$ = GDP per capita growth.

Table A 3.5: Descriptive statistics

	$ED_{i,t}$	$PCED_{i,t}$	$CPV_{i,t}$	$CP_{i,t}$	$PCCP_{i,t}$	$RIR_{i,t}$	$FDI_{i,t}$	$CAB_{i,t}$	$GDP_{i,t}$
Mean	61.02	0.92	8.50	111.68	4.73	7.38	4.82	−5.46	2.69
Median	43.71	−1.44	6.51	111.25	4.52	7.17	3.26	−4.31	2.62
Maximum	1252.42	300.07	36.65	192.57	27.80	77.61	84.94	43.39	33.03
Minimum	3.89	−80.42	0.91	47.72	−35.27	−98.15	−37.16	−80.05	−22.55
Std. Dev.	72.11	25.19	7.82	50.16	18.19	11.26	6.26	10.20	4.25
Skewness	7.52	3.90	2.29	0.26	−0.50	−1.29	3.73	−0.95	0.20
Kurtosis	93.02	39.26	8.70	1.58	2.47	18.04	31.87	7.90	9.00
Observations	1660	1660	1660	1660	1660	1660	1660	1660	1660

Table A 3.6: Correlation matrix

	$PCED_{i,t}$	$CPV_{i,t}$	$PCCP_{i,t}$	$RIR_{i,t}$	$FDI_{i,t}$	$CAB_{i,t}$	$GDP_{i,t}$
$PCED_{i,t}$	1.00						
$CPV_{i,t}$	0.01	1.00					
$PCCP_{i,t}$	−0.25	0.10	1.00				
$RIR_{i,t}$	0.09	−0.07	−0.14	1.00			
$FDI_{i,t}$	0.007	0.09	0.06	−0.005	1.00		
$CAB_{i,t}$	−0.09	−0.08	0.02	−0.11	−0.55	1.00	
$GDP_{i,t}$	−0.23	0.04	0.23	−0.01	0.13	0.08	1.00

Appendix 3.2

A 3.2.1. Pooled OLS model

In the pooled OLS models, we have pooled all the observations in OLS regression meaning that implicitly we assume the coefficient is the same for all the individuals. So, we can write the model (3.1) by the following form –

$$PCED_{i,t} = \beta_0 + \beta_1 PCED_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 RIR_{i,t} + \beta_5 FDI_{i,t} + \beta_6 CAB_{i,t} + \beta_7 GDP_{i,t} + \varepsilon_{i,t} \quad (3.4)$$

A 3.2.2. RE models

In the RE, the variation across entities is assumed to be random and uncorrelated with the independent variables included in the model. The rationale behind the random effect models is that, unlike the fixed effect models, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. The random-effects model includes all fixed effect assumptions plus the additional requirement that (Ψ_i) is independent of all explanatory variables in all time periods. Hence, the variability of the constant for each section comes from:

$$\beta_{0i} = \beta_0 + \Psi_i \quad (3.5)$$

Where Ψ_i is a zero-mean standard random variable. Therefore equation (3.4) with random effects takes the following form-

$$PCED_{i,t} = \beta_0 + \beta_1 PCED_{i,t-1} + \beta_2 CPV_{i,t} + \beta_3 PCCP_{i,t} + \beta_4 RIR_{i,t} + \beta_5 FDI_{i,t} + \beta_6 CAB_{i,t} + \Psi_i + \beta_7 GDP_{i,t} + \varepsilon_{i,t} \quad (3.6)$$

We estimate equation (3.4) and (3.6) for all country groups mentioned above.

A 3.2.3. Hausman test

Null hypothesis: RE model is appropriate

Alternative hypothesis: FE model is appropriate

Table A 3.7: Results of the Hausman test

Country groups	Chi-Sq. Statistics	*p*-value	Comments
Full Sample	149.29	0.00	Reject Null hypothesis
Commodity-exporting countries	49.84	0.00	Reject Null hypothesis
Commodity-importing countries	103.11	0.00	Reject Null hypothesis

From Table A 3.7, we can observe that the *p*-value of the Hausman test is less than 5% indicating that we can reject the null hypothesis and accept the alternative hypothesis that the FE model is appropriate. This result is consistent for all three country groups.

Appendix 4.1

Table A 4.1: Description of the variables

Variables	Mnemonic	Description	Source
Dependent variable			
Real GDP per capita	$LGDP_{i,t}$	GDP per capita is gross domestic product divided by mid-year population. Data are in constant 2010 US dollars.	WDI, WB
Control variables			
Oil rents (% of GDP)	$LOIL_{i,t}$	Oil rents are the difference between the value of crude oil production at regional prices and total costs of production. We add 1 before converting into logarithmic form.	WDI, WB
Unemployment rate (% of total labour force)	$LUN_{i,t}$	Unemployment rate can be defined by the OECD harmonised definition. The OECD harmonised unemployment rate gives the number of unemployed persons as a percentage of the labour force.	WEO, IMF
Foreign direct investment, net outflows (% of GDP)	$LFDI_{i,t}$	Foreign direct investment refers to direct investment equity flows in an economy. It is the sum of equity capital, reinvestment of earnings, and other capital. We add 100 before converting into logarithmic form.	WDI, WB
Current account balance (% of GDP)	$LCAB_{i,t}$	Current account balance is the sum of net exports of goods and services, net primary income and net secondary income. We add 250 before converting into logarithmic form.	WDI, WB
Military expense (% of GDP)	$LMI_{i,t}$	Military expenditures data from SIPRI are derived from the NATO definition, which includes all current and capital expenditures on the armed forces. We add 1 to convert logarithmic form.	WDI, WB
Mortality rate, infant (per 1,000 live births)	$LMOR_{i,t}$	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.	WDI, WB
Trade openness (% of GDP)	$LT_{i,t}$	Trade is the sum of exports and imports of goods and services measured as a share of GDP.	WDI, WB

Note: We use first difference to get the data in stationary in real GDP per capita series and expressed as $\Delta LGDP_{i,t}$ in equation 4.1.

Table A 4.2: List of countries (n = 95)

Albania	China	Indonesia	Mexico	Serbia
Algeria	Colombia	Iran	Moldova	Seychelles
Argentina	Costa Rica	Irelands	Mongolia	Singapore
Armenia	Croatia	Israel	Morocco	Slovak Rep.
Australia	Cyprus	Italy	Netherlands	Slovenia
Austria	Czech Rep.	Jamaica	New Zealand	South Africa
Azerbaijan	Denmark	Japan	Nicaragua	Spain
Bahrain	Dominican Rep.	Jordan	Nigeria	Sri Lanka
Belarus	Ecuador	Kazakhstan	Norway	Sweden
Belgium	Egypt, Arab Rep.	Korea, Rep.	Pakistan	Switzerland
Belize	El Salvador	Kuwait	Panama	Thailand
Bolivia	Estonia	Kyrgyz Rep.	Paraguay	Tunisia
Bosnia & Herzegovina	Finland	Latvia	Peru	Turkey
Brazil	France	Lithuania	Philippines	Ukraine
Brunei Darussalam	Georgia	Luxemburg	Poland	The UK
Bulgaria	Germany	Macedonia	Portugal	The USA
Cabo Verde	Greece	Malaysia	Romania	Uruguay
Canada	Honduras	Malta	Russian Federation	Venezuela
Chile	Hungary	Mauritius	Saudi Arabia	Vietnam

Table A 4.3: Unit root test

	Augmented Ducky–Fuller (ADF)				Phillips–Peron (PP)			
	At level		1st difference		At level		1st difference	
	statistics	*p*-value	statistics	*p*-value	statistics	*p*-value	statistics	*p*-value
LGDP	138.67	0.99	1,062.80	0.00	151.79	0.98	1,156.21	0.00
LOIL	315.05	0.00	-	-	301.44	0.00	-	-
LUN	362.38	0.00	-	-	364.88	0.00	-	-
LFDI	509.65	0.00	-	-	923.37	0.00	-	-
LCAB	429.20	0.00	-	-	459.19	0.00	-	-
LMI	235.43	0.00	-	-	278.75	0.00	-	-
LMOR	229.90	0.02		--	390.70	0.00	-	-
LT	276.40	0.00	-	-	298.34	0.00	-	-

Note: LGDP = Log of real GDP per capita, LOIL = Log of oil rent, LUN = Log of unemployment rate, LFDI = Log of foreign direct investment, LCAB = Log of current account balance, LMI = Log of military expense, LMOR = Log of mortality rate, LT = Log of trade openness.

Table A 4.4: Descriptive statistics

	ΔLGDP	LOIL	LUN	LFDI	LCAB	LMI	LMOR	LT
Mean	0.02	0.56	1.98	4.62	5.51	1.06	2.41	4.29
Median	0.02	0.04	2.01	4.61	5.51	1.02	2.39	4.28
Maximum	0.28	4.13	3.61	5.76	5.68	3.05	4.76	6.08
Minimum	–0.18	0.000	–3.68	2.33	5.32	0.00	0.53	2.44
Std. Dev.	0.03	0.90	0.64	0.11	0.02	0.46	0.87	0.56
Skewness	–0.35	1.83	–0.80	–5.42	0.62	0.54	0.17	0.11
Kurtosis	7.28	5.66	6.50	162.17	9.06	4.11	2.29	3.54
Observations	2506	2506	2506	2506	2506	2506	2506	2506

Note: ΔLGDP = Change in log of real GDP per capita, LOIL = Log of oil rent, LUN = Log of unemployment rate, LFDI = Log of foreign direct investment, LCAB = Log of current account balance, LMI = Log of military expense, LMOR = Log of mortality rate, LT = Log of trade openness.

Table A 4.5: Correlation matrix

	ΔLGDP	LOIL	LUN	LFDI	LCAB	LMI	LMOR	LT
ΔLGDP	1.00							
LOIL	–0.02	1.00						
LUN	–0.03	–0.14	1.00					
LFDI	0.008	–0.01	–0.04	1.00				
LCAB	–0.09	0.36	–0.26	0.07	1.00			
LMI	–0.06	0.18	–0.02	–0.02	0.15	1.00		
LMOR	0.04	0.28	0.17	–0.14	–0.20	0.09	1.00	
LT	0.13	–0.16	–0.17	0.09	0.06	–0.19	–0.32	1.00

Note: ΔLGDP = Change in log of real GDP per capita, LOIL = Log of oil rent, LUN = Log of unemployment rate, LFDI = Log of foreign direct investment, LCAB = Log of current account balance, LMI = Log of military expense, LMOR = Log of mortality rate, LT = Log of trade openness.

Appendix 4.2

A 4.2.1. Pooled OLS model

In the pooled OLS model, we have pooled all the observations in ordinary least square regression, meaning that implicitly we assume the coefficient is the same for all the individuals. This model does not hold any unobservable heterogeneity among the variables. We can write equation (4.1) in following way:

$$\Delta LGDP_{i,t} = \beta_0 + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + \beta_5 LCAB_{i,t} + \beta_6 LMI_{i,t} + LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \varepsilon_{i,t} \quad (4.3)$$

A 4.2.2. FE model

We use the fixed effect model to further investigate the effect of oil rent on economic growth. The fixed effect model essentially captures all effects that are specific to an individual country and do not vary over time. For example, GDP per capita, trade and oil rent will vary between countries due to their differing geographies, natural endowments, political and cultural systems and other basic factors that vary between countries, but not over time. Fixed effect model assumes that these factors may have an impact on the predictor or outcome variable, and we need to control for this. Fixed effect model removes the effect of those time-invariant characteristics so that we can assess the net impact of oil rent on economic growth. We can write equation (4.1) with fixed effect as follows:

$$\Delta LGDP_{i,t} = \beta_{0i} + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + LCAB_{i,t} + \beta_6 LMI_{i,t} + \beta_7 LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \varepsilon_{i,t} \quad (4.4)$$

Where β_{0i} is the unobserved, time-invariant individual effect.

A 4.2.3. PFE model

In this study, we also apply period fixed effect model. This model essentially captures all effects that are specific to the periods and do not vary over countries. Macroeconomic variables such as GDP, trade, reserve and capital can vary over time. For example, technological development or international agreements can change productivity growth globally which increases output over time. Period fixed effect model removes the effect of those country-invariant characteristics so that we can assess the net impact of oil rent on economic growth. We can write equation (4.1) with fixed effect as follows:

$$\Delta LGDP_{i,t} = \beta_{0t} + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + \beta_5 LCAB_{i,t} + \beta_6 LMI_{i,t} + \beta_7 LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \varepsilon_{i,t} \quad (4.5)$$

Where β_{0t} is the unobserved, country-invariant individual effect.

A 4.2.4. RE model

The rationale behind the random effect model is that, unlike the fixed effect model, the variation across countries is assumed to be random and uncorrelated with the predictor or independent variables included in the model. For example, in the random effect model it is assumed that an unobserved effect (e.g., geographical factors, natural endowments, political and cultural systems) are not correlated with economic growth. The random effect model includes all fixed effect assumptions plus the additional requirement that (Ψ_i) is independent of all explanatory variables in all time periods. Thus, the variability of the constant for each section comes from:

$$\beta_{0i} = \beta_0 + \Psi_i \quad (4.6)$$

Where Ψ_i is a zero-mean standard random variable. Therefore, equation (4.3) with random effect takes the following form:

$$\Delta LGDP_{i,t} = \beta_0 + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + \beta_5 LCAB_{i,t} + \beta_6 LMI_{i,t} + \beta_7 LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \Omega_i + \varepsilon_{i,t} \quad (4.7)$$

A 4.2.5. PRE model

This model assumes that variation is arising over time to be random and uncorrelated with the independent variables included in the model. So, we can rewrite equation (4.7) as:

$$\Delta LGDP_{i,t} = \beta_0 + \beta_1 \Delta LGDP_{i,t-1} + \beta_2 LOIL_{i,t} + \beta_3 LUN_{i,t} + \beta_4 LFDI_{i,t} + \Sigma_{i=0}^{n} \beta_5 LCAB_{i,t} + \beta_6 LMI_{i,t} + \beta_7 LMOR_{i,t} + \beta_8 LT_{i,t} + \beta_9 LT_{i,t} * LOIL_{i,t} + \Omega_t + \varepsilon_{i,t} \quad (4.8)$$

Where Ω_t is a zero-mean standard random variable that is independent of all explanatory variables in all countries.

Appendix 4.3

A 4.3. Robustness check

A 4.3.1. Alternative measures of trade openness

To check the robustness of the results, we use two alternative measures of trade openness: exports and imports. Tables A 4.6 and A 4.7 represent the empirical findings of the impact of oil rent on economic growth interacting with the two alternative measures of trade openness. From both tables, we find that the coefficient of oil rent is negative and significant, indicating that economic growth decreases with the increase of oil rent. Conversely, the positive coefficient of log in exports indicates that economic growth increases with the increase of exports. The coefficient of the interaction term between log in export and log in oil rent is positive and significant, indicating that the negative impact of oil rent on economic growth reduces with the increase of exports. The government's total income will increase with the increase in export that increases real GDP per capita.

Table A 4.6: Change in real GDP per capita and oil rent in terms of export (1980-2017)

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.40***	0.46***	0.36***	0.46***	0.51***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LOIL_{i,t}$	–0.03***	–0.01**	–0.03***	–0.01**	–0.01***	–0.01***
	(0.009)	(0.005)	(0.01)	(0.005)	(0.004)	(0.004)
	[0.01]	[0.008]	[0.01]	[0.008]	[0.007]	[0.007]
$LUN_{i,t}$	–0.0005	0.0008	–0.0004	0.0008	–0.0001	–0.0002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.0009)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	–0.003	0.002	0.004	0.002	–0.003	–0.003
	(0.005)	(0.008)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	–0.12***	–0.06***	–0.11***	–0.06***	–0.07***	–0.07***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.03]	[0.05]	[0.03]	[0.03]	[0.03]
$LMI_{i,t}$	–0.01***	–0.002*	–0.01***	–0.002*	–0.001	–0.001
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01***	0.002***	0.01***	0.002***	0.001**	0.001**
	(0.004)	(0.0008)	(0.002)	(0.0008)	(0.0008)	(0.0008)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.0009]	[0.0009]
$LEX_{i,t}$	0.004	0.003**	0.009**	0.003**	0.002**	0.002**
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LEX_{i,t}$*$LOIL_{i,t}$	0.01***	0.004***	0.01***	0.004***	0.003***	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
	[0.003]	[0.002]	[0.004]	[0.002]	[0.002]	[0.002]
R^2	0.47	0.26	0.33	0.26	0.42	0.30
Adjusted R^2	0.44	0.26	0.30	0.26	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2,499	2,499	2,499	2,499	2,499	2,499

Note: $LEX_{i,t}$ indicates log in exports (% of GDP). Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in square brackets.

We observe a similar pattern in results when we look at Table A 4.7, where we use imports as an alternative measure of trade openness. Economic growth increases with the increase of imports and the negative impact of oil rent on economic growth decrease with the increase of imports. A country can hire new technologies and high-tech products by allowing

import openness. Moreover, import helps to increase efficiency in the managerial level by exchanging advanced knowledge between economies.

Table A 4.7: Change in real GDP per capita and oil rent in terms of import (1980–2017)

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.41***	0.46***	0.36***	0.46***	0.51***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LOIL_{i,t}$	–0.02***	–0.01**	–0.02**	–0.01**	–0.01***	–0.01***
	(0.009)	(0.006)	(0.01)	(0.006)	(0.005)	(0.005)
	[0.01]	[0.007]	[0.01]	[0.007]	[0.006]	[0.006]
$LUN_{i,t}$	–0.0006	0.0008	–0.0005	0.0008	–0.0002	–0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.0009)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	–0.002	0.002	0.005	0.002	–0.003	–0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.003]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	–0.02	–0.01	0.01	–0.01	–0.03	–0.03
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.05]	[0.03]	[0.05]	[0.03]	[0.03]	[0.03]
$LMI_{i,t}$	–0.01***	–0.002*	–0.02***	–0.002*	–0.001	–0.001
	(0.03)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.005]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01***	–0.002***	0.01***	–0.002***	0.001**	0.001**
	(0.004)	(0.0008)	(0.002)	(0.0008)	(0.0008)	(0.0008)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.0009]	[0.0009]
$LIM_{i,t}$	0.007**	0.003***	0.01***	0.003***	0.002**	0.002**
	(0.003)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
	[0.006]	[0.001]	[0.006]	[0.001]	[0.001]	[0.001]
$LIM_{i,t}$*$LOIL_{i,t}$	0.008***	0.005***	0.009***	0.005***	0.004***	0.004***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
	[0.003]	[0.002]	[0.003]	[0.002]	[0.001]	[0.001]
R^2	0.47	0.26	0.32	0.26	0.42	0.30
Adjusted R^2	0.44	0.26	0.30	0.25	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2,499	2,499	2,499	2,499	2,499	2,499

Note: $LIM_{i,t}$ indicates log in imports (% of GDP). Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in square brackets.

A 4.3.2. Alternative measures of resource abundance

We use natural resource rent instead of oil rent to check the resource curse hypothesis and the impact of trade openness on economic growth. Table A 4.8 presents the empirical findings of the nexus between natural resource rent and economic growth interacting with trade openness with different dynamic panel data models. The coefficient of natural resource rent is negative, indicating that economic growth decreases with the increase of natural resource rent and the estimated elasticity is –0.05. All other things being equal, a one per cent increase in natural resource rents is associated with a significant decrease in the economic growth of over 0.05 per cent. This negative association between economic growth and natural resource rents provides evidence of the resource curse.

The coefficient of the interaction term between trade openness and natural resource rent is also positive, indicating that a more open trade regime lessens the negative impact of natural resource rent on economic growth. These results are significant ($p = 0.01$) and consistent with different time and country fixed effect and random effect models. Tables A 4.9 and A 4.10 show the impact of natural resource rent on economic growth in terms of exports and imports and find that both export and import reduce the resource course.

Table A 4.8: Change in real GDP per capita and natural resource rent in terms of trade openness (1980-2017)

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.40***	0.46***	0.36***	0.46***	0.51***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LNR_{i,t}$	–0.05***	–0.01**	–0.05***	–0.01***	–0.01***	–0.01***
	(0.01)	(0.006)	(0.01)	(0.005)	(0.005)	(0.005)
	[0.02]	[0.008]	[0.02]	[0.007]	[0.007]	[0.007]
$LUN_{i,t}$	–0.0006	0.0007	–0.0006	0.0007	0.0009	0.0002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.0009)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	–0.003	0.002	0.005	0.002	–0.003	–0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	–0.06**	–0.03	–0.03	–0.03	–0.05**	–0.04**
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.03]	[0.04]	[0.02]	[0.02]	[0.02]
$LMI_{i,t}$	–0.01	–0.002	–0.01***	–0.002	–0.001	–0.001
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01***	0.002***	0.01***	0.002***	0.001**	0.001**
	(0.004)	(0.0009)	(0.002)	(0.0008)	(0.0008)	(0.0008)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$LT_{i,t}$	0.002	0.002	0.01**	0.002*	0.002	0.002
	(0.004)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
	[0.005]	[0.002]	[0.005]	[0.002]	[0.002]	[0.002]
$LT_{i,t}*LNR_{i,t}$	0.01***	0.004***	0.01***	0.004***	0.003***	0.003***
	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
R^2	0.48	0.26	0.33	0.26	0.42	0.30
Adjusted R^2	0.45	0.26	0.30	0.26	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2,499	2,499	2,499	2,499	2,499	2,499

Note: $LNR_{i,t}$ indicates log in natural resource rent (% of GDP). Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in square brackets.

Table A 4.9: Change in real GDP per capita and natural resource rent in terms of export (1980-2017)

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.40***	0.46***	0.36***	0.46***	0.51***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LNR_{i,t}$	- 0.04***	- 0.01**	- 0.04***	- 0.01**	- 0.01***	- 0.01***
	(0.009)	(0.004)	(0.01)	(0.004)	(0.004)	(0.004)
	[0.01]	[0.007]	[0.01]	[0.007]	[0.006]	[0.006]
$LUN_{i,t}$	- 0.0003	0.0007	- 0.0002	0.0007	0.0001	0.0002
	(0.0009)	(0.001)	(0.001)	(0.001)	(0.0009)	(0.0009)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	- 0.003	0.002	0.004	0.002	- 0.003	- 0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	- 0.12***	- 0.06	- 0.11***	- 0.06	- 0.07***	- 0.07***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.04]	[0.03]	[0.05]	[0.03]	[0.03]	[0.03]
$LMI_{i,t}$	- 0.01	- 0.002	- 0.01***	- 0.002	-0.001	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.004]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01**	0.002***	0.01***	0.002***	0.001**	0.001**
	(0.004)	(0.0009)	(0.002)	(0.0008)	(0.0008)	(0.0008)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$LEX_{i,t}$	-0.002	0.002	0.002	0.002	0.001	0.001
	(0.003)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
	[0.005]	[0.002]	[0.005]	[0.002]	[0.001]	[0.002]
$LEX_{i,t}$*$LNR_{i,t}$	0.01***	0.004***	0.01***	0.004***	0.003***	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.002]	[0.002]	[0.002]	[0.001]	[0.001]
R^2	0.48	0.26	0.33	0.26	0.42	0.30
Adjusted R^2	0.48	0.26	0.30	0.26	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2499	2499	2499	2499	2499	2499

Note: Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in [].

Table A 4.10: Change in real GDP per capita and natural resource rent in terms of import (1980-2017)

	Dependent variable: $\Delta LGDP_{i,t}$					
	Combined model (1)	pooled OLS (2)	FE (3)	RE (4)	PFE (5)	PRE (6)
$\Delta LGDP_{i,t-1}$	0.41***	0.46***	0.36***	0.46***	0.51***	0.50***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
$LNR_{i,t}$	- 0.02***	- 0.01**	- 0.02**	- 0.01**	- 0.01***	- 0.01***
	(0.009)	(0.005)	(0.01)	(0.005)	(0.004)	(0.004)
	[0.01]	[0.005]	[0.01]	[0.005]	[0.005]	[0.005]
$LUN_{i,t}$	- 0.0005	0.0006	- 0.0002	0.0006	0.0003	0.0001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.0009)	(0.0009)
	[0.002]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
$LFDI_{i,t}$	- 0.002	0.002	0.005	0.002	- 0.003	- 0.003
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
$LCAB_{i,t}$	- 0.01***	- 0.003	- 0.03	- 0.003	- 0.02	- 0.02
	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
	[0.05]	[0.03]	[0.05]	[0.03]	[0.03]	[0.03]
$LMI_{i,t}$	- 0.01***	- 0.002*	- 0.01***	- 0.002*	-0.001	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
	[0.004]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$LMOR_{i,t}$	0.01**	0.002***	0.01***	0.002***	0.001*	0.001*
	(0.004)	(0.0009)	(0.005)	(0.0008)	(0.0008)	(0.0008)
	[0.005]	[0.001]	[0.002]	[0.001]	[0.001]	[0.001]
$LIM_{i,t}$	0.002	0.003*	0.01	0.003*	0.002	0.002
	(0.004)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
	[0.007]	[0.002]	[0.007]	[0.002]	[0.002]	[0.002]
$LIM_{i,t}$*$LNR_{i,t}$	0.008***	0.003***	0.01***	0.003***	0.003***	0.003***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
	[0.003]	[0.001]	[0.003]	[0.001]	[0.001]	[0.001]
R^2	0.47	0.26	0.32	0.26	0.42	0.30
Adjusted R^2	0.44	0.26	0.29	0.26	0.41	0.30
Periods	38	38	38	38	38	38
Countries	95	95	95	95	95	95
Observations	2499	2499	2499	2499	2499	2499

Note: Standard errors are presented below the corresponding coefficients in the bracket. The asterisks ***, ** and * indicate the significance at the 1%, 5%, and 10% level, respectively. Cluster standard errors are presented in [].

Appendix 4.4

In figures A 4.1.a, A 4.1.b, and A 4.1.c, we present the marginal effect of oil rent on economic growth in terms of exports for full sample period, and subsample periods 1980-1994 and 1995-2017 respectively.

Figure A 4.1.a: Marginal effect of oil rent on economic growth (1980-2017)

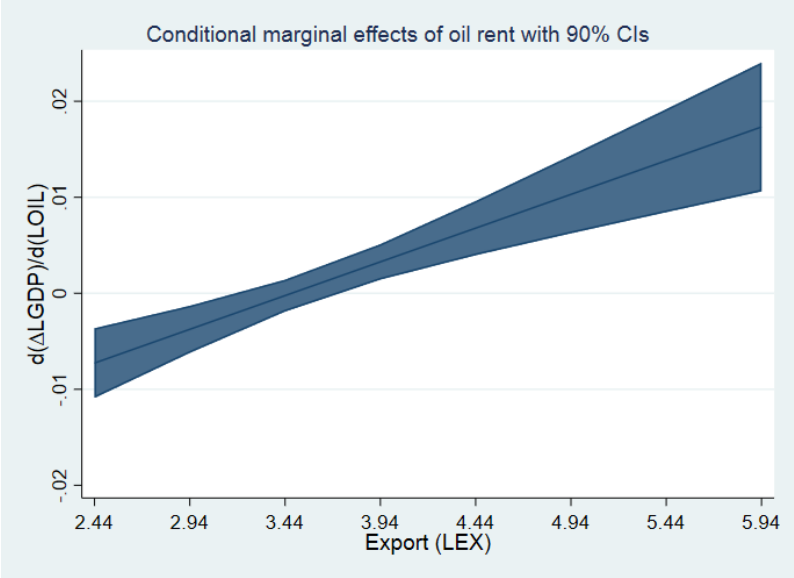


Figure A 4.1.b: Marginal effect of oil rent on economic growth (1980-1994)

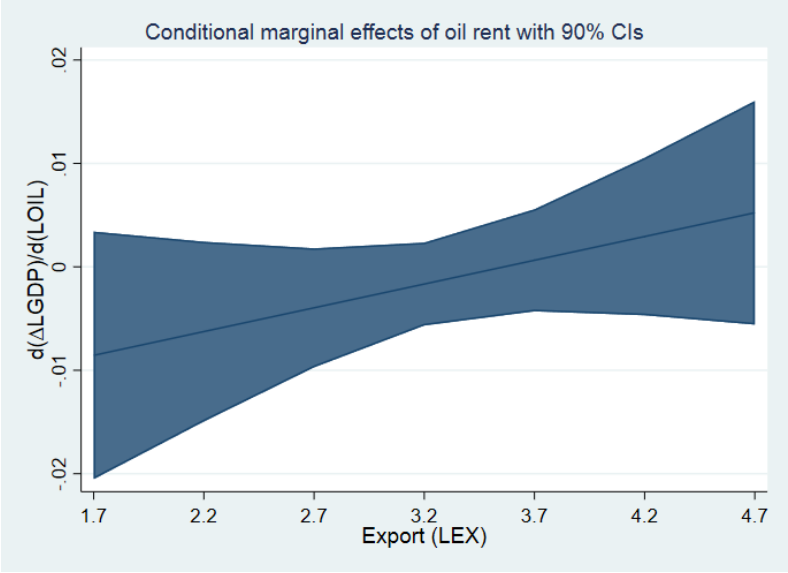
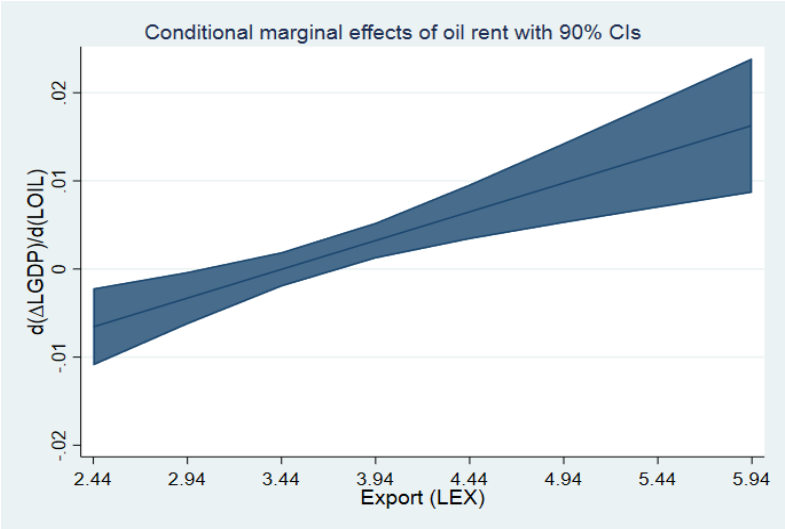


Figure A 4.1.c: Marginal effect of oil rent on economic growth (1995-2017)



In figures A 4.2.a, A 4.2.b, and A 4.2.c, we present the marginal effect of oil rent on economic growth in terms of imports for full sample period, and subsample periods 1980-1994 and 1995-2017 respectively.

Figure A 4.2.a: Marginal effect of oil rent on economic growth (1980-2017)

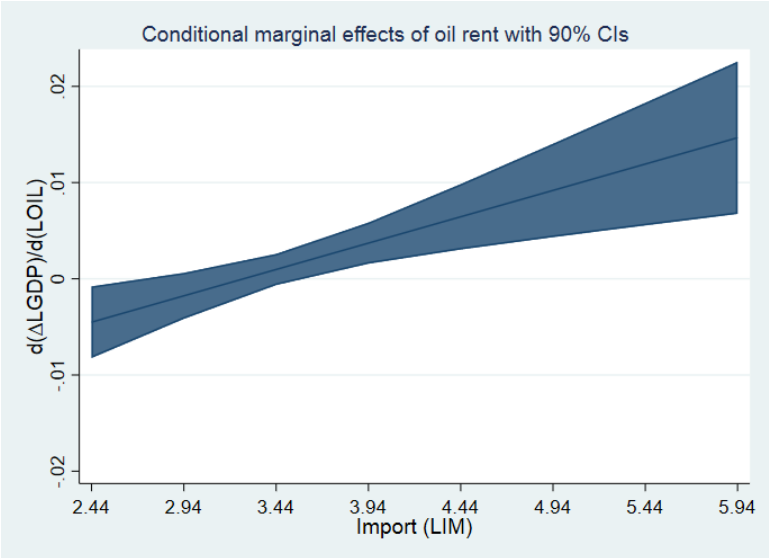


Figure A 4.2.b: Marginal effect of oil rent on economic growth (1980-1994)

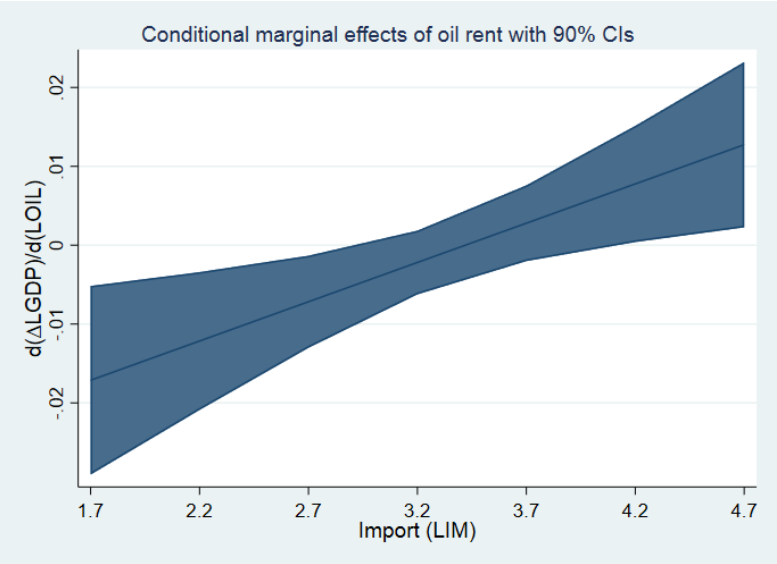
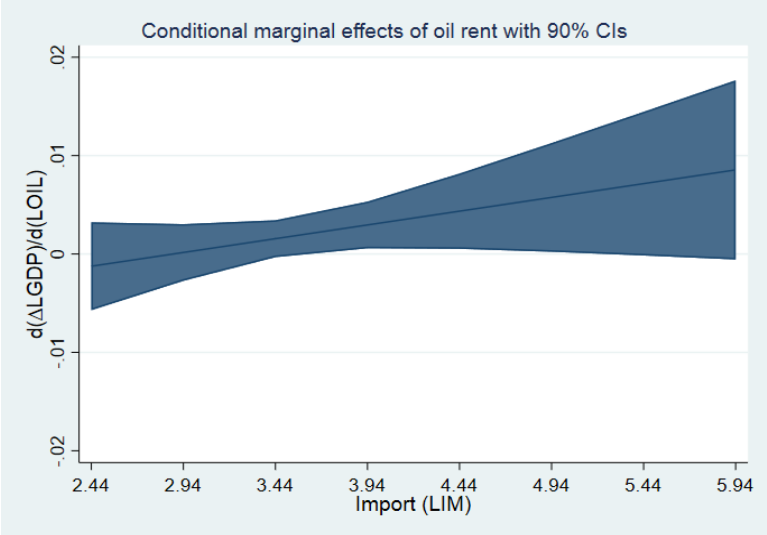


Figure A 4.2.c: Marginal effect of oil rent on economic growth (1995-2017)



In figures A 4.3.a, A 4.3.b, and A 4.3.c, we present the marginal effect of natural resource rent on economic growth in terms of trade openness for full sample period, and subsample periods 1980-1994 and 1995-2017 respectively.

Figure A 4.3.a: Marginal effect of natural resource rent on economic growth (1980-2017)

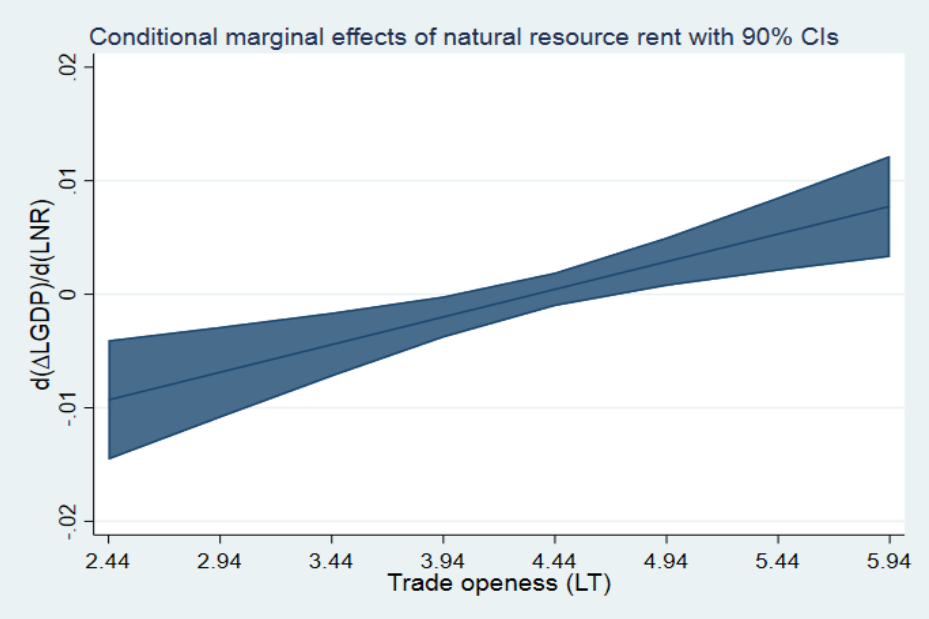


Figure A 4.3.b: Marginal effect of natural resource rent on economic growth (1980-1994)

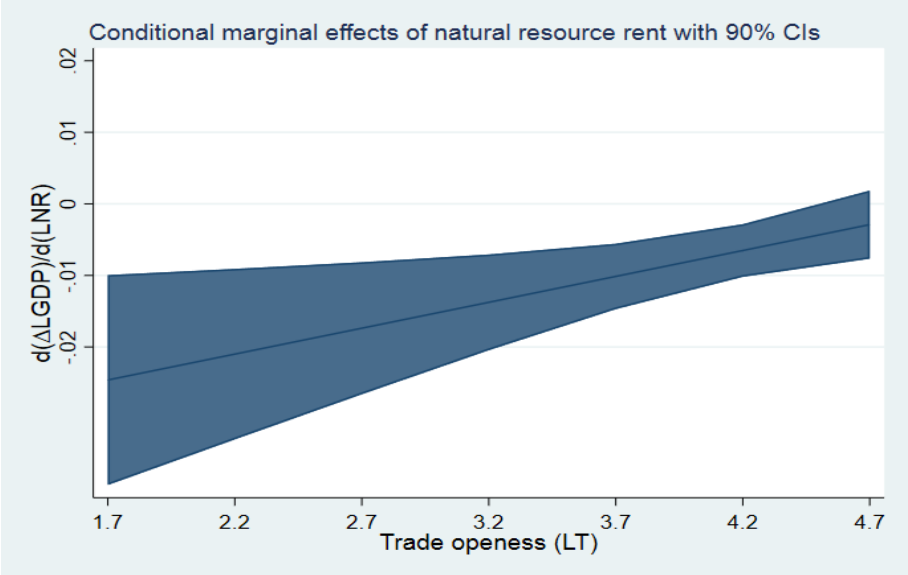
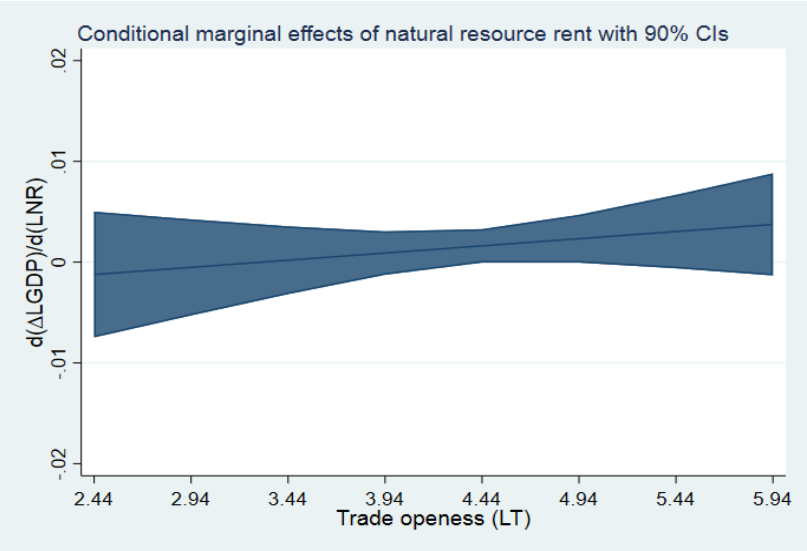


Figure A 4.3.c: Marginal effect of natural resource rent on economic growth (1995-2017)



In figures A 4.4.a, A 4.4.b, and A 4.4.c, we present the marginal effect of natural resource rent on economic growth in terms of exports for full sample period, and subsample periods 1980-1994 and 1995-2017 respectively.

Figure A 4.4.a: Marginal effect of natural resource rent on economic growth (1980-2017)

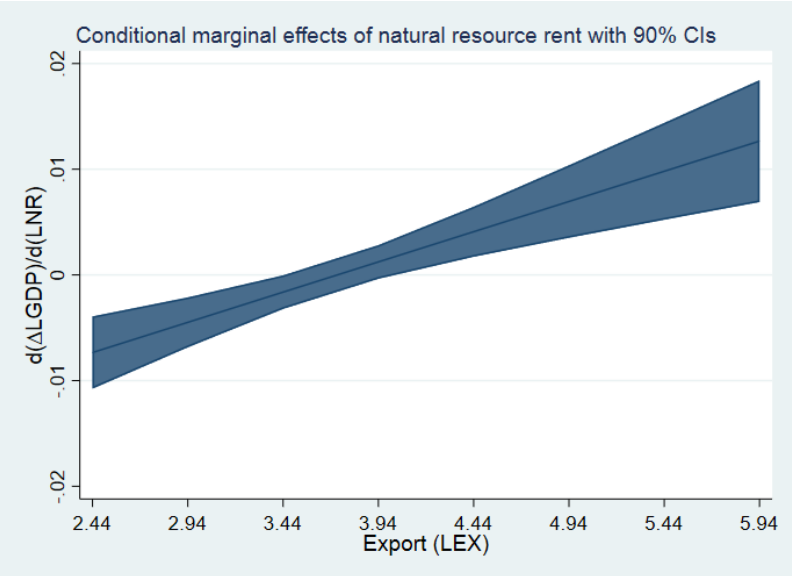


Figure A 4.4.b: Marginal effect of natural resource rent on economic growth (1980-1994)

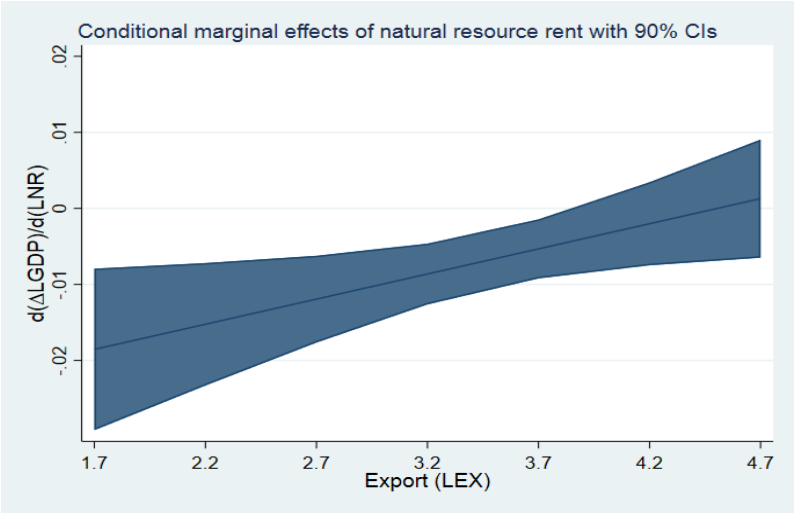
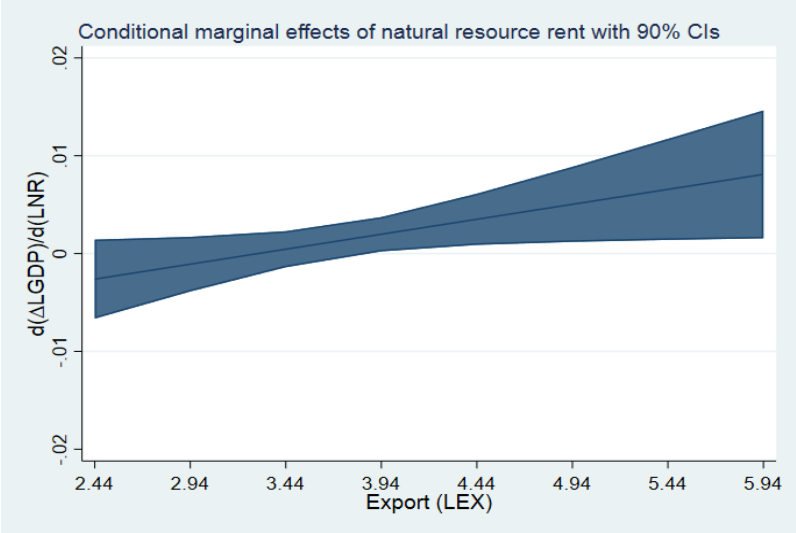


Figure A 4.4.c: Marginal effect of natural resource rent on economic growth (1995-2017)



In figures A 4.5.a, A 4.5.b, and A 4.5.c, we present the marginal effect of natural resource rent on economic growth in terms of imports for full sample period, and subsample periods 1980-1994 and 1995-2017 respectively.

Figure A 4.5.a: Marginal effect of natural resource rent on economic growth (1980-2017)

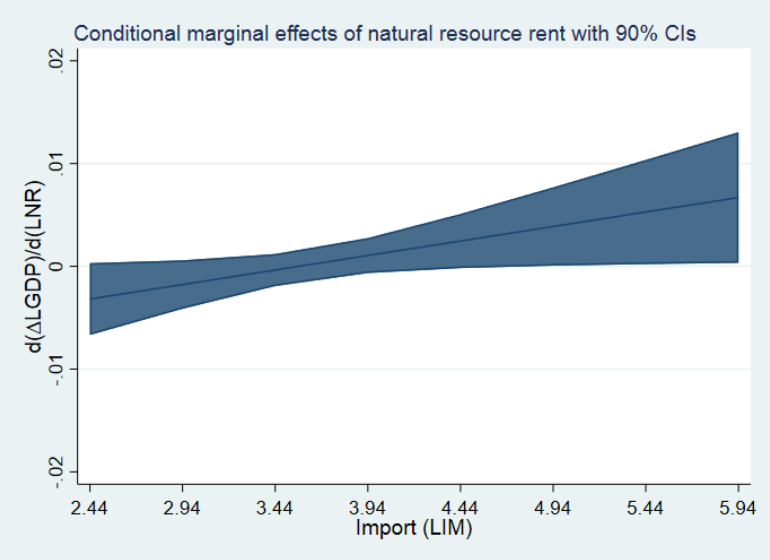


Figure A 4.5.b: Marginal effect of natural resource rent on economic growth (1980-1994)

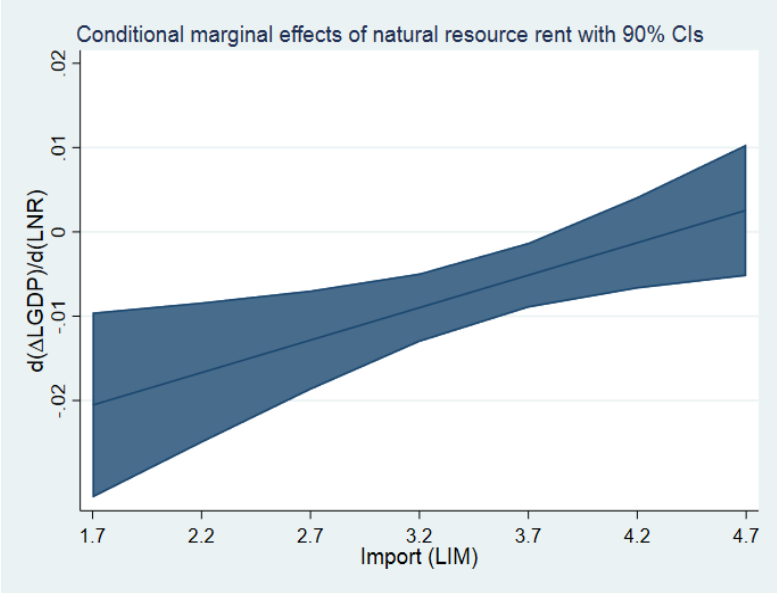
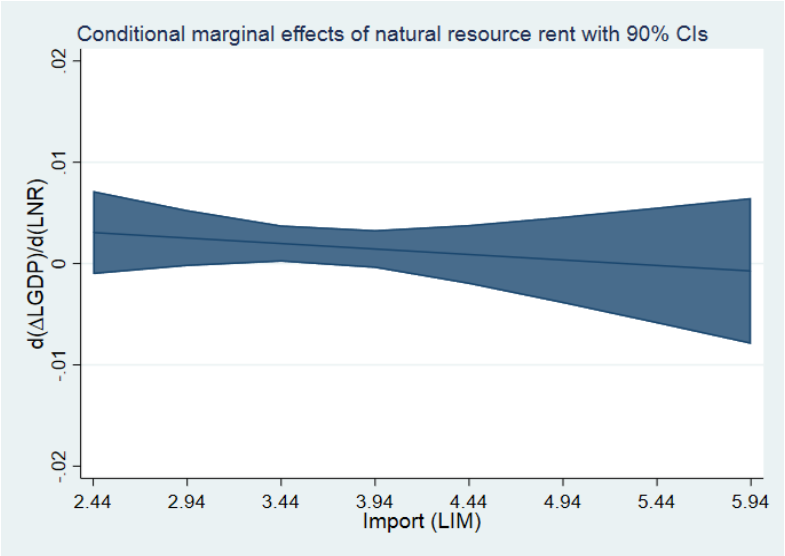


Figure A 4.5.c: Marginal effect of natural resource rent on economic growth (1995-2017)



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